



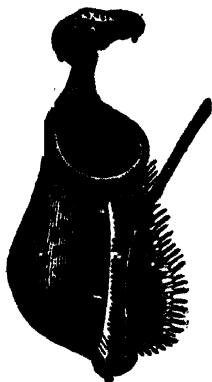
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OF  
**STRUCTURAL BOTANY:**

FOR THE USE OF  
CLASSES, SCHOOLS, & PRIVATE STUDENTS.

By M. C. COOKE.



WITH UPWARDS OF 200 ILLUSTRATIONS BY RUFFLE  
THIRTY-SECOND THOUSAND.

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1886.

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## P R E F A C E.

HAVING experienced the want of a cheap Manual to place in the hands of students in the Botanical Classes established for Operatives, in connection with the Department of Science and Art, I have made this effort to supply the want in the manner which, to my judgment, appeared best calculated to render it serviceable to them. I have purposely divided the Manual into Forty Sections, corresponding with the Forty Lessons which the Department requires should be given. Each of these sections contains an outline of the chief points necessary to be demonstrated to a Class at the respective lessons, unencumbered with such illustrations as a teacher would give, but which would needlessly have swelled this volume and augmented its price. In its present form, it is calculated to refresh the memory of the student concerning the past, rather than, of itself, instruct him in the future of his studies. No attempt has been made to popularize the subject;—this must be considered rather as a skeleton of dry details, to be filled up and attired according to the taste of the demonstrator. The Illustrations are not intended to supersede diagrams, drawings, and the liberal use of the black board, but

as helps for those who may not be able to use the pencil with sufficient facility in their note-books. The orthography and etymology of the technicalities of this branch of the science will, it is hoped, prove an assistance to the teacher, as there will be less necessity for him to write up every new term as it occurs, so as to familiarize his pupils with its orthography. No note has been taken of Economic Botany. Information of this kind is more readily obtainable, and the oral instruction which the teacher may give in the course of his demonstrations, will be more popular in its character and more easily remembered.

Independently of the primary object of the work, it is believed that it will be found useful to the young botanist and private student as a prelude to other and more expensive treatises.

M. C. C.

*November, 1861.*

### NOTE TO THE PRESENT EDITION.

A NEW edition of this Manual being demanded, it has been thoroughly revised; the Chemical nomenclature corrected, to bring it into harmony with the requirements of advanced science, and several minor alterations adopted, which, it is hoped, will greatly improve the work, and ensure for it a continuance of public favour.

# A MANUAL OF STRUCTURAL BOTANY.

## SECTION L INTRODUCTORY.

WE are accustomed to regard the whole of the material world as divisible into three great *kingdoms*, i. e., mineral, vegetable, and animal. It is not so easy to determine the limits of the latter two, as to distinguish them from the former, so intimately do they blend into each other. No definition has yet been attempted to which exception might not be taken. The old distinction that animals live and move; that plants live, but do not move; and that minerals neither live nor move; will only hold good to a certain extent, for we have *fixed* animals and *moving* plants; although animals are generally possessed of, and plants deficient in, the power of locomotion. Another distinction, that plants respire oxygen under the influence of light, and animals carbonic acid gas, was accepted, until certain plants, of a low organization, were found to respire carbonic acid gas under all circumstances. Chlorophyll and starch were supposed to be exclusively vegetable products till the former was discovered in the fresh-water hydra, and the latter in the  
of man.



Dr. Lankester gives the following distinctions :—

“ I. Plants derive their nourishment from mineral or inorganic substances, animals from organized matters.

“ II. Plants absorb their nutriment to a greater or lesser extent by their whole external surface, whilst animals possess a mouth, and take up their nutriment from an internal bag or stomach.

“ III. Plants are mostly fixed, whilst animals have a power of moving about. To this distinction, however, there are numerous exceptions.

“ IV. The tissues of plants are distinguished by the tendency to absorb carbonic acid and throw off oxygen, whilst those of animals absorb oxygen and throw off carbonic acid gas.

“ V. Both plants and animals are developed from an impressible and motile protoplasm, but in animals this substance becomes differentiated into nerves and muscles.”—(Lectures on Botany,—Science and Art Department.)

The study of all that relates to the vegetable kingdom is included in the science of *Botany*.

I. That department of the science of Botany which has reference to the textures of which plants are composed, and the forms of their organs, is termed *Structural Botany*, *Vegetable Anatomy*, or *Organo-graphy*.

This department of the science may be regarded as again subdivided into *Vegetable Histology*, which confines itself to the tissues of plants, and *Vegetable Morphology*, which treats of the forms of the various organs.

II. The second department of Botanical Science is that in which plants are considered as living beings, and which takes especial cognizance of their vital functions. It is therefore termed *Physiological Botany*.

The aid of Chemistry and the allied sciences is

requisite for a thorough acquaintance with these departments.

III. Another department concerns itself with all that relates to the arrangement and classification of plants, and is termed *Systematic Botany*. The knowledge of this depends on an acquaintance with the former divisions of the science.

IV. The distribution of plants over the surface of the globe forms another division, which, from its intimate connection with geography, is termed *Geographical Botany*.

V. *Fossil Botany*, or a special study of the vegetable remains found deposited in geological formations, links Botany with Geology, and being based upon the results obtained in the former divisions of the science, applies them in elucidation of the plant-history of the past. It has also been called *Geological Botany*.

These departments have been named in the order in which they should be studied. The first and second only will be treated of in this volume, not separately but simultaneously, the functions of the organs with the descriptions of their forms.

The title selected must therefore be accepted in a broad and general sense as embracing these two subdivisions, and not as restricted to one.

## SECTION II.

### THE ULTIMATE ELEMENTS OF PLANTS.

An *Element*, or simple substance, contains, so far as we know, but one kind of matter. Sixty-five elements in various forms of combination make up the whole mass of the earth, air, and water.

Fifteen elements invariably occur in plants and animals. These elements are found combined together in the vegetable and the animal structures as *compounds*.

When a plant is burnt, some of its elements enter into new combinations, become *volatile*, and are dissipated in the air as gases or vapours. The volatile elements of plants are four—oxygen, hydrogen, nitrogen, and carbon.

The non-volatile or *fixed* elements of plants are eleven in number ; viz., phosphorus, sulphur, silicon, fluorine, chlorine, potassium, sodium, calcium, magnesium, iron, and manganese.

Phosphorus, sulphur, and fluorine are sometimes found in the volatile part of plants, while, on the other hand, in the fixed part, carbon and oxygen always occur, nitrogen rarely. Two other elements, iodine and bromine, are contained in seaweeds, while several additional metals, copper, aluminium, zinc, and rubidium, have been detected in particular plants.

#### ELEMENTS OF THE VOLATILE PART OF PLANTS.

**O**, Symbol ; atomic weight, 16. OXYGEN (*Oxys*, acid ; *gennao*, I produce) is only known as a gas. The atmosphere contains in 100 measures 21 of oxygen and 79 of nitrogen, another elementary gas. The majority of the compounds which form the food of plants contain much oxygen ; of these compounds, *carbon dioxide*, often called carbonic acid, contains 2 atoms of oxygen and 1 atom of carbon ( $\text{CO}_2$ ), while another, *water*, contains 2 atoms of hydrogen and 1 atom of oxygen ( $\text{H}_2\text{O}$ ). Plants have the power, under the solar influence, of decomposing carbon dioxide and other oxygen compounds. In the case of carbon dioxide the carbon is retained by the plant and re-combined with other elements, and the oxygen is

set free. Thus the atmosphere is purified and supplied afresh with oxygen, the great supporter of combustion and life. In the putrefaction of vegetable and animal matters oxygen is absorbed, and they thus once more return to the inorganic or mineral world.

**H,** Symbol ; 1, atomic weight. HYDROGEN (*Hydor*, water ; *gennao*, I produce) is only known as a gas. It is the lightest body in nature. Burnt in the air, it combines with oxygen, forming water. Water enters into the composition of plants, and through the agency of water they take up a large proportion of the materials of their structure.

**N,** Symbol ; 14, atomic weight. NITROGEN (*Nitron*, nitre ; *gennao*, I produce) is only known as a gas. It is chemically inactive. Combined with hydrogen it forms *ammonia* ( $\text{NH}_3$ ), with hydrogen and oxygen *nitric acid* ( $\text{HNO}_3$ ).

**C,** Symbol ; 12, atomic weight. CARBON (*Carbo*, coal) is a solid element existing in three different states,—the diamond, graphite or blacklead, and charcoal or lamp-black. When burnt, carbon yields carbon dioxide, a gas which is also evolved in the oxidation of the carbon of food which goes on in the animal body.

#### THE FIXED ELEMENTS OF PLANTS.

**P,** Symbol ; 31, atomic weight. PHOSPHORUS (*Phos*, light ; *phero*, I bring) is a wax-like solid in one of its forms. It does not naturally occur free, but only in combination with metals as phosphides, or with metals and oxygen as phosphates. It is extremely inflammable, and emits light by slow combustion at the ordinary temperature.

**S**, Symbol ; 32, atomic weight. **SULPHUR** (*Sal*, salt ; *pyr*, fire) is a brittle, yellow, combustible solid, which melts and vaporizes by heat. Sulphur and hydrogen unite to form an offensive-smelling gas, hydrosulphuric acid ( $\text{H}_2\text{S}$ ) ; with oxygen it unites, burning with a blue flame and forming sulphur dioxide ( $\text{SO}_2$ ), a pungent gas. Sulphates contain sulphur, a metal, and oxygen ; sulphuric acid, sulphur, hydrogen, and oxygen ( $\text{H}_2\text{SO}_4$ ).

**Si**, Symbol ; 28, atomic weight. **SILICON** (*Silex*, flint). United with oxygen, silicon forms a dioxide called silica ( $\text{SiO}_2$ ). This is common as flint, agate, sand, and quartz, and enters largely into the composition of the stems of meadow grasses and wheat.

**F**, Symbol ; 19, atomic weight. **FLUORINE** (*Fluo*, I flow) is found in minute quantity in many, perhaps in all, plants. Combined with calcium it forms the mineral fluorspar ( $\text{CaF}_2$ ), and in this state occurs in bones and teeth.

**Cl**, Symbol ; 35.5, atomic weight. **CHLORINE** (*Chloros*, green) is known usually as a gas of a pale greenish-yellow colour and suffocating odour. Combined with sodium it constitutes common salt, sodium chloride ( $\text{NaCl}$ ). A compound of chlorine, calcium, and oxygen ( $\text{CaCl}_2\text{O}_2$ ) is used for disinfection and bleaching. This element occurs abundantly in marine and maritime plants.

**I**, Symbol ; 127, atomic weight. **IODINE** (*Iodes*, violet-coloured). A heavy, greyish-black, lustrous and crystallized solid, which turns on heating into a violet-coloured vapour. It stains the skin yellow, and gives with starch a rich blue colour : it occurs in seaweeds as metallic iodide.

**Br,** Symbol ; 80, atomic weight. **BROMINE** (*Bromos*, stench), a heavy, deep brownish-red liquid, which gives off a vapour of the same colour and of disagreeable odour.

**K,** Symbol ; 39, atomic weight. **POTASSIUM** (*Potashes*), a bluish-white soft metal, lighter than water, and decomposing at ordinary temperatures. Potassium is more abundant in cultivated than in wild plants. It occurs in them as chloride and sulphate, and in the salts of the vegetable acids.

**Na,** Symbol ; 23, atomic weight. **SODIUM** (*Natrium*, from *natron*, native sodium carbonate) is a silver-white metal, rather lighter than water. In its occurrence and uses in plants it closely resembles potassium.

**Ca,** Symbol ; 40, atomic weight. **CALCIUM** (*Calx*, lime). Its oxide is lime ( $\text{CaO}$ ), its hydrate, slaked lime ( $\text{CaH}_2\text{O}_2$ ), and its carbonate, chalk and whitening ( $\text{CaCO}_3$ ). Calcium carbonate is dissolved by water holding carbon dioxide in solution. Many plants contain much calcium, as oxalate, citrate, &c.

**Mg,** Symbol ; 24, atomic weight. **MAGNESIUM** (Magnesia, in Asia Minor) is a silver-like metal, which burns with a brilliant white light when heated, and forms magnesia ( $\text{MgO}$ ). It occurs abundantly in the grain of wheat.

**Fe,** Symbol ; 56, atomic weight. **IRON** (*Ferrum*, iron). The presence of iron in plants seems connected with their green colour.

**Mn.** Symbol ; 55, atomic weight. **MANGANESE** occurs in minute quantity in plants ; but it is a variable ingredient.

Of the other metals found in plants copper seems most generally diffused, though it occurs in very small traces only.

### SECTION III.

#### CARBONACEOUS COMPOUNDS.

**CELLULOSE** ( $C_6H_{10}O_5$ ) is a compound of carbon, hydrogen, and oxygen. It constitutes the basis of vegetable tissues. The elastic transparent membrane of cell-walls is composed of this substance, which is permeable by fluids. It is allied to starch, becomes yellow on the addition of iodine, and when acted upon by sulphuric acid and iodine, assumes a blue colour.

**LIGNINE** is found deposited upon cellulose, forming the woody fibres of plants, and giving strength and solidity. When lignine is submitted to the action of sulphuric acid, it is converted into glucose.

**STARCH** ( $C_6H_{10}O_5$ ) is a common product of plants. It exists in the form of granules, or minute cells, which become blue upon the addition of iodine. These granules possess such distinctive features in size and shape, that the mixture of the starch from one kind of plant with that of another may be detected by the microscope. They are ordinarily oblong, spheroidal bodies or flattish discs, marked with parallel striations. Some are of very irregular form. In almost all instances there is a central spot or hilum, and the series of lines arrange themselves around it. There is also a cell-wall, but no central cavity. The markings

are supposed to be produced either by the foldings of the cell-walls, or by the successive layers of starch.

This substance is insoluble in cold water ; when submitted to the action of boiling water, the cells swell, the cell-walls burst, their contents are discharged, and the mass becomes a tenacious paste. Starch is found in almost all the cellular parts of plants, but is most plentiful in roots and tubers, and in the grains of cereals.



Fig. 1.

Starch is convertible by heat into dextrine, or by the action of boiling weak sulphuric acid, into a mixture of dextrine and glucose (grape sugar), and ultimately into glucose.

Plants contain more starch at certain periods than at others. During germination and at the time of flowering much of it is converted into sugar. It is this conversion of starch into sugar during germination which has been taken advantage of in the process of malting, to convert the starch of grain into sugar by forced germination.

*Inuline* is a variety of starch, obtained from dahlia tubers, elecampane, Jerusalem artichoke, and some few other plants.

*Lichenine* ( $C_6H_{10}O_5$ ) is the peculiar starch of lichens. It is found in Iceland moss (*Cetraria Islandica*), Rein-deer moss (*Cænomyce rangiferina*), and carrageen, or Irish moss (*Chondrus crispus*).

**DEXTRINE** ( $C_6H_{12}O_5$ ). During the change of starch into sugar, an intermediate stage occurs in which the starch is converted into dextrine or soluble starch ; for it is then soluble in water. Starch must first be converted into dextrine or sugar before it can afford nourishment to the growing parts of plants.



**SUGAR** may be said to exist in plants under three forms.

*Cane sugar* ( $C_{12}H_{22}O_{11}$ ), which is found in the sugar-cane, maple, and beet-root. This is not a fermentable sugar, but must first be converted into glucose.

*Grape sugar*, or *glucose* ( $C_6H_{12}O_6$ ), gives sweetness to most fruits, is a product of the metamorphoses of starch, cane sugar, and woody fibre. This is fermentable.

*Mannite* ( $C_6H_{14}O_6$ ) is an unfermentable sugar found in the manna ash, mushrooms, celery, some sea-weeds and other plants.

**GUM** ( $C_{12}H_{22}O_{11}$ ) is one of the substances produced abundantly in plants. It exists in many seeds, exudes from the stems and branches of trees, and is found in the juices of others. It may be considered as a fixed dextrene.

The following are its chief varieties :—

*Arabine*, soluble in cold water. *Ex.* Gum arabic.

*Bassorine*, partly soluble. *Ex.* Gum tragacanth.

*Cerasine*, insoluble part of cherry gum.

*Pectine*, gelatinous. *Ex.* Pulpy fruits.

*Mucilage*, present in mallows and linseed.

**RESINS** contain much carbon and hydrogen, with little or no oxygen. They are found in plants, sometimes in a fluid state, called balsams and oleo-resins, and at other times solid. The most important solid resins are the copals, or those which partake of their character. These substances are insoluble in water, but soluble in spirits of turpentine.

**ORGANIC ACIDS** are produced by processes going on

in living plants, and exist in vegetable juices, often combined with peculiar bases and alkaloids.

PECTOSE and other neutral compounds of carbon, hydrogen, and oxygen are also found in fruits and roots.

*Acetic acid* ( $C_2H_4O_2$ ) occurs in plants as potassium acetate.

*Citric acid* ( $C_6H_8O_7$ ) occurs in fruits of the orange tribe.

*Tartaric acid* ( $C_4H_6O_6$ ) occurs in the juice of the grape.

*Malic acid* ( $C_4H_6O_5$ ) occurs in the apple, gooseberry, &c.

*Tannic acid* ( $C_{27}H_{22}O_{17}$ ) in oak and other barks.

*Hydrocyanic acid* ( $CyH$  where  $Cy$  is  $=CN$ ) in cherry-laurel leaves.

*Oxalic acid* ( $C_2H_2O_4$ ) with potash in sorrel, rhubarb, and other plants.

*Gallic acid* ( $C_7H_6O_5$ ) in all kinds of galls by the conversion of tannic acid.

**VOLATILE OILS.** The chemical composition of these oils is extremely various. They are obtained by distillation from various aromatic plants. Oils from coniferous trees consist generally of carbon and hydrogen only. Otto of roses and oils from labiate plants contain oxygen in addition; whilst the oils of alliaceous plants contain sulphur also. Many volatile oils deposit *stearoptine*, which is nearly allied to camphor.

*Camphor* ( $C_{15}H_{16}O$ ). This may be considered as a sort of solid volatile oil, less widely diffused, and only obtained commercially from two or three species of plants. It is light, inflammable, and evaporates on exposure to the air.

**CAOUTCHOUC.** A hydrocarbon, very widely diffused through plants, but more profusely developed in tropical regions. It is found associated with resin in the milky juices of many kinds of figs and euphorbias.

**FIXED OILS** contain carbon, hydrogen, and oxygen. When decomposed they yield fat—acids, and glycerine. Found most abundantly in the seeds of plants. They generally congeal at a lower temperature than the freezing-point of water, but some are solid at the ordinary temperature of the air. They all require a high temperature for their evaporation. Olive oil is found in the fruit.

**WAX** A kind of fatty matter found in the fruits and stems of plants sometimes covering the fruit with a “bloom,” or appearing in scaly masses upon the stems. It is soluble in ether, insoluble in water, and combustible.

#### SECTION IV.

#### NITROGENOUS COMPOUNDS

There are certain nitrogenous products found in plants, most commonly in greatest quantity in the seeds. These are termed flesh-formers or albuminoids, as they serve to build up the flesh of animals, and are closely related to *albumen*, the white of the egg. They consist of carbon, oxygen, hydrogen, and nitrogen, with some sulphur.

**FIBRINE** is the essential part of the gluten of wheat, the grey elastic mass which is left when dough is long washed in water.

**CASEINE** or *Legumine* is an essential part of the seeds of leguminous plants ; it is also the chief flesh-former in milk.

**ALBUMEN** occurs in a soluble form in the expressed juice of many plants : it coagulates or separates in flocks when liquids are heated to 60°—70° centigrade.

These three nitrogenous compounds are seldom found alone. In the juice of potatoes there is, besides fibrine and albumen, vegetable caseine ; and in leguminous seeds there is always, besides the caseine, a certain quantity of albumen.

**EMULSINE** is a nitrogenous compound found in oily seeds, as in almonds. In bitter almonds it is associated with *amygdaline*, and the two, when boiled with water, yield hydrocyanic acid, and oil of bitter almonds.

**DIASTASE** is a nitrogenized substance procured from malt, and developed during the germination of seeds. It is an albuminoid in an altered state, and has the power of converting starch into sugar.

The following table shows the proportions of digestible nitrogenous products and carbo-hydrates in 100 parts of the edible portions of certain plants :—

	Water.	Nitro- genous.	Carbo- hydrates.	Ashes.
Peas .....	14	23	52	2·5
Beans .....	14	25·5	46	3·5
Lentils .....	14	24	52	2·6
Oats .....	14	12	61	3
Barley .....	14	9	66	2·8
Potatoes ....	75	2	21	1
Turnips ....	89	1	9	1

**ALKALOIDS** are nitrogenous compounds found in plants, and generally constitute their active principles. They usually occur combined with organic acids.

*Quinine* ( $C_{20}H_{24}O_2N_2$ ) exists in cinchona barks.

*Morphine* ( $C_{17}H_{19}ON_3$ ) exists with others in opium.

*Solanine* ( $C_{43}H_{71}NO_{16}$ ) is found in plants of the potato tribe.

*Veratrine* ( $C_{72}H_{52}O_2N_2$ ) occurs in sebadilla.

*Aconitine* ( $C_3H_4NO_7$ ) is found in monkshood and other species of aconite.

*Strychnine* ( $C_{21}H_{22}N_2O_2$ ) is the active principle of nux vomica.

*Atropine* ( $C_{17}H_{23}O_3N$ ) the active principle of belladonna.

*Piperine* ( $C_{14}H_{15}O_6N_2$ ) is found in pepper.

*Theine* or *Caffeine* ( $C_8H_{11}N_4O_2$ ), the principle of tea and coffee.

**CHLOROPHYLL.** The green colouring matter of plants; generally occurs in a granular form, floating in the fluid contents of cells. It partakes somewhat of the character of wax, and is only developed under the influence of light, and in the presence of iron.

## SECTION V.

### MINERAL COMPOUNDS.

As a prelude to the mineral compounds, an important constituent of vegetable structures in their vital state must not be forgotten, *i.e.* water.

**WATER** ( $H_2O$ ) is found in many aquatic plants to the extent of 90 per cent. Potatoes contain 75 per cent, turnips 90, and carrots 80 per cent. A sunflower consumes daily 22 ounces of water; consequently, if every plant occupies 4 square feet of soil, the plants of one acre would require 1,826,706 lb. during the four summer months. But the ground around the plants would also sustain grass and weeds, which require water to an equal extent at least. Therefore 3 million pounds of water would be required for an acre of sunflowers. It has been estimated that an acre of cabbages would require 5 million pounds, and an acre of hops 6 or 7 million pounds of water. Through the agency of this fluid, plants take up most of the elements of their composition. Much of this is absorbed by means of the roots.

The water and combustible portion of plants form by far the greatest proportion,—the mineral or incombustible being seldom present, even in their dried state, to the amount of 10 per cent.

The mineral matter, or ash left after incineration, varies in different plants, and in different parts of the same plant. In the dried leaves of the elm, more than 10 per cent. of mineral matter exists, while the wood affords less than 2 per cent.

In 1,000 lb. of the grain, and the same quantity of the straw of wheat, the following mineral substances are found :—

	Grain.	Straw.
Potash ( $K_2O$ ) .....	5.5	4.9
Soda ( $Na_2O$ ) .....	.6	1.2
Lime ( $CaO$ ) .....	.6	2.6
Magnesia ( $MgO$ ) .....	2.2	1.1
Silica ( $SiO_2$ ) .....	.3	28.2
Sulphur trioxide .....	.4	1.2
Phosphorus pentoxide .....	8.2	2.3
	<hr/> 17.8 lb.	<hr/> 41.5 lb.

These substances are variously combined, as sulphates, phosphates, and chlorides ; the silica, however, is mostly free.

The large proportion of silica in the above analyses shows its importance to plants of the grass tribe.

As all these fixed substances must be derived by plants from the soil in a state of solution, it becomes important to ascertain the quality of the soil, and its fitness to supply the requisite materials to the plants we would cultivate.

The importance of such a consideration is thus beautifully illustrated by Schleiden, the celebrated German botanist :—

“ The beautiful orchidaceous plant, the ladies’ slipper, grows over all parts of the Swiss Fore Alps, where the soil is formed of the alpine limestone ; it accompanies the whole Swabian muschelkalk, and disappears suddenly when we come to the sand of the Jura and Keuper formations on this side of the Danube. It next makes its appearance on the muschelkalk of Thuringia, and comes down with that on the Werra as far as the neighbourhood of Göttingen, then leaps over the Bunter sandstone of the Lower Eichsfeld, the granite of the Upper Hartz, and again gladdens the eye of the wanderer on the calcareous formations eastward of the Brocken. It is sought in vain over all the clay and sand formation of the northern German plains, till in the extreme north it again shows itself at Rügen, where the chalk rocks of Arkona and Stubbenkammer lift their heads.

“ On the western coast of France grow various insignificant-looking shore plants, species of *Salsola* and *Salicornia*, which the inhabitants there use to obtain soda from the ashes. When we travel from thence towards the east, we everywhere miss these little plants, even when searching most carefully, and

merely one or other of them makes its appearance in such places where the soil is moistened by some salt spring. At last we arrive at the Great Steppes of the south-east of Russia, which in summer are often covered with a thick crust of salt, showing themselves to be the ancient bottom of some dried-up sea, and here these plants are found growing in the same abundance and luxuriance as in the west of France. On the northern coast of Germany the little pale-red maiden pink grows upon the arid sand dunes, and is universally distributed over the sandy plains of northern Germany; but these are succeeded by the granite, clay, slate, and gypsum of the Hartz, the porphyry and muschelkalk of Thuringia, and our little pink is not met with again till we arrive at the Keuper sand plains, on the further side of the Maine, surrounding the venerable city of Nuremberg. It extends farther south, through the Palatinate, till the muschelkalk of the Suabian Alps again sets a limit to it; but it leaps over these and the whole alpine region, and at last appears on the sandy soils of northern Italy. How is it that these plants everywhere disdain the richest soils in their range of geographical distribution, and are confined to perfectly determinate geognostic formations? Must not the lime, salt, and sand (or silex) have a most distinct influence in the matter?"

Of the elements of plants, only oxygen and nitrogen occur free or uncombined in them. The other elements are variously combined together: some of these compounds are here given:—

Water,  $H_2O$ .

Carbon dioxide = carbonic acid gas,  $CO_2$ .

Ammonia with various acids.



Nitrates, such as potassium and calcium nitrates.

Sulphates, such as potassium and calcium sulphates.

Phosphates, such as calcium and magnesium phosphates.

Chlorides, such as sodium and potassium chlorides.

Oxalates,

Citrates,

Tartrates,

Acetates,

} as those of calcium and potassium.

*Raphides* (Gr. needles) are crystals, or clusters of crystals, commonly of calcium oxalate, but also sometimes of the phosphate, tartrate, sulphate, or carbonate. They are found generally in cells (*Fig. 2*), and occasionally in great numbers. Turkey rhubarb root contains above 30 per cent.



*Fig. 2.* contains above 30 per cent.

## SECTION VI.

### CELLS.

The simplest form of vegetable life, and the most elementary phase from which all others are developed, is that of a minute *vesicle*, or cell.



CELLS are very small transparent bladders, or cysts, with walls, or boundaries, of *cellulose*, and generally contain fluids.

An egg may be accepted as an illustration of a cell, of which the shell represents the cell-wall.

The normal form of the cell is that of a sphere, or spheroid, having a length not much exceeding its

breadth (*Fig. 3*). An aggregation of these cells, or vesicles, constitutes the *cellular tissue* of plants.

Were the cell-walls to retain their original form when compacted together, there would be numerous spaces left unoccupied between the points of attachment; these might be termed *intercellular spaces* or *lacunæ* (*lacuna*, Lat. a little hole).

Slight pressure causes the cells to accommodate themselves to the space they have to occupy, and they assume that form which shall best fill up the interstices and occupy the least room, namely, a modification of the dodecahedral with an hexagonal section (*Fig. 5*). Hence, this is the most common form in the cellular portions of plants

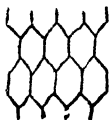
The simplest plants, as algæ and fungi (*Fig. 4*), consist entirely of cellular tissue, and are hence called *Cellulares*.

The pith of trees, rushes (*Fig. 7*), and the rice-paper of the Chinese, are cellular, as are also all plants in their earliest stages.

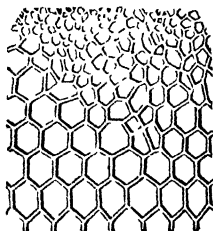
*Parenchyma* (Gr. for the substance of the lungs, liver, &c.) is the name generally given to cellular tissue which exhibits hexagonal cells when cut across.



*Fig. 4.*



*Fig. 5.*



*Fig. 6.*

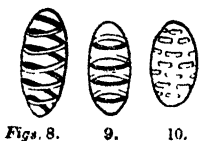


*Fig. 7.*

When a spiral line is coiled up in the interior of

cells, it is called *Fibro-cellular* tissue (*Fig. 8*). This is a very common form.

The spiral is sometimes broken up, so that the thread appears in rings (*Fig. 9*), and, when still more broken, in bars, or portions of rings, or elongated dots (*Fig. 10*).



Figs. 8.

9.

10.

The spiral thread is deposited within upon the cell-wall subsequent to the formation of the cell itself. It sometimes becomes free, and at others remains attached.

The spiral threads and movable fibres which are found in the antheridia of mosses, and elsewhere in cryptogamic plants, and which exhibit peculiar movements, so as at one time to have been considered as animalculæ, are doubtless of this nature and origin.

The microscope is necessary for the examination of all cell-structures.

The membrane of the cell-wall permits the circulation of fluids through it, although pores are not often visible.

A kind of cellular tissue consisting of short cylindrical cells, is called *Pitted tissue*. These may originally have been spheroidal cells, the walls of which have become ruptured in one direction so as to assume a cylindrical character (*Fig. 11*).



Fig. 11

The walls of these tubes are pitted or dotted, in consequence of the unequal deposit in their interior. It is a very common form of tissue in wood, and conveys fluids with facility in the direction of its length.

As all forms of tissue are derived from the simple cell, of which they are but subsequent modifications, intermediate forms will be met with of all the varieties, and the line of demarcation can scarcely be fixed, the division or

classification under different names being more artificial than natural, serving to mark phases of the same tissue, rather than to be designations of different elementary organs.

The terms *cellular* and *vascular* tissue are still employed, with this limitation of the meaning and value attached to them.

## SECTION VII

### VASCULAR TISSUE.

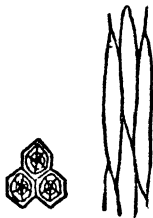
Under the general name of *Vascular tissue* is included the form of tissue which, with greater propriety, is termed *woody tissue*, or *pleurenchyma* (*pleura*, Gr. a rib), and *fibro-vascular* tissue.

WOODY TISSUE consists of elongated tubes of a fusiform or spindle shape, tapering at each end. It is cylindrical, long, fine, and tough, characteristics which distinguish it from cellular tissue.

It is found in the wood, inner bark, and veins of leaves.

The walls of this kind of tissue become thickened by successive layers of lignine, and when cut in section, the concentric lines or markings of the successive deposits may often be traced (*Fig. 12*).

The strength of this kind of tissue renders it extremely valuable in the arts, when divested by maceration of all extraneous matters. In this way hemp, flax, China grass, Manilla hemp, &c. are prepared. The distinct forms of woody tissue in linen,



*Fig. 12.*

and cellular tissue in cotton, are easily detected under the microscope.

*Glandular woody tissue* is a peculiar variety of *parenchyma*, occurring in coniferous and some few other plants.

The sides of the tubes are furnished with circular disks, sometimes in single, and at others in double or triple rows. These disks or depressions have small orifices in their centre (Figs. 13, 14).



A recognition of this kind of tissue in coal determines its coniferous or cycadaceous origin.

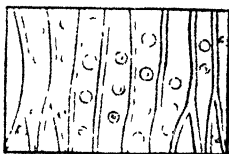


Fig 14.

**VASCULAR, or Fibro-**  
**Fig. 13.** vascular tissue, consists of thin cylindrical tubes, with fibre spirally coiled up within them. It has also been called *Trachenchyma* (*trachea*, Lat. windpipe).

*Spiral vessels* are the type of this kind of tissue. These vessels, which are fusiform (spindle-shaped), overlap at the ends, where, the intervening membrane being absorbed, they communicate freely with each other. They are found in the medullary sheath, veins of leaves, &c.



Fig 15.

The fibre in the interior may be unrolled, and is sometimes single; and at others several fibres are united together, side by side, and may be unrolled like a ribbon.

When the spiral fibre is broken up, or does not make a complete coil in the tube, a modification of the above kind of tissue results, called *ducts* or *false tracheæ*, to which special names are also given, according to the phases it assumes.

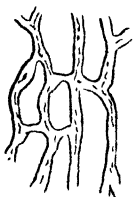
When the fibre occurs in rings, it is called *annular*.

When the tubes are prismatic, and the fibre is

broken and arranged at equal distances above each other, like the steps of a ladder, it is termed *scalariform* (*scalæ*, Lat. a ladder), as in ferns (*Fig. 16*).

Sometimes the arrangement is very irregular.

These ducts seem to convey fluids.

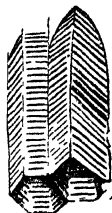


*Fig. 17.*

*Laticiferous vessels*, or *Cinenchyma* (*kineo*, Gr. I move), are branched tubes, which unite and run into each other in a very irregular manner, forming a complete network (*Fig. 17*).

The walls are not marked. It commonly occurs in the liber of Exogens.

These vessels convey a fluid called *latex*, which is either transparent or coloured. It has of late been suspected to be of a formative character.



*Fig. 16.*

## SECTION VIII.

### CELL DEVELOPMENT.

The history of the development of cells is still confused. Much as has been written, the entire question is one of considerable uncertainty.

Schleiden has referred the origin of cells to the formation of a central point amongst the formative fluid, around which a congregation of atoms takes place till a firm layer is formed; this becomes ultimately the cell-wall, which enlarges, assimilates fluid, and becomes a cell, containing within it the *nucleus*, or, as he terms it, *cytoblast* (*kutos*, Gr. a cell; *blastos*, a germ).

Cells have generally, when full grown, a thickened disk, or *nucleus*, of this kind, attached to their sides, and these sometimes contain other bodies, called *nucleoli* (*Fig. 18*).



Fig. 18.

New cells may be formed on the outside of old cells, as branches; this process has been termed *gemmation*, or budding. This fact has been proved in the growth of *sea-weeds* (*Fig. 19*).



Fig. 19.

New cells may also be produced from old cells by *fissuration*, or internal subdivision.

A division, or septum, separates the old cell into two portions, each of which becomes a complete cell. (This is shown in *Fig. 20*.)



Fig. 20.

Another theory assumes that the *nucleus* separates into parts, each forming the new nucleus, around each of which a new cell wall is developed, and ultimately the old cell-wall is ruptured and disappears.

These methods may be characterized as :—

- 1st. *Isolated* formation in mucus.
- 2nd. *Gemmation*, or *Exogenous* formation.
- 3rd. *Fissuration*, or by division of cells.
- 4th. *Endogenous*, or by division of nucleus.

Cells increase with immense rapidity, especially in some fungi. Dr. Lindley estimates that in *Bovista gigantea*, the great puff-ball, cells are developed at the rate of 66,000,000 per minute.

Spiral threads owe their origin to internal deposits in cells. It is not improbable that gum, derived from the transformation of starch, is the chief agent.

Truncated or tubular cells appear to be derived from a congeries of cells, placed in apposition, and

under circumstances of pressure or circulation favourable to the final obliteration of their walls in the direction of their attachment.

Similarly may the laticiferous tubes have originated in part from such truncated cells, which have at the same time become branched and anastomosed, so that all trace of their origin is obliterated.

The *Contents* of cells are—

The *primordial utricle*, or *protoplasm*, which is the deposited lining of the cell-wall.

Deposits of *sclerogen* (makes hard), in layers, give great solidity to some cells. *Ex.* Vegetable ivory.

*Water*, generally containing other matters in solution.

*Jelly*, which is perhaps the same as *pectin*, the mucilage which abounds in some algæ.

*Starch*, *chlorophyll*, *chromule* (colouring matter other than green), *wax*, *oil*, *camphor*, *resin*, and *raphides*.

Other compounds are found deposited in the *vascular* system.

## SECTION IX.

### THE EPIDERMIS.

The external cellular covering of plants, or *epidermal* layers, may be readily detached from young leaves and stems for examination.

The *Epidermis* (*epi*, Gr. upon; *derma*, skin) is extended over all parts of plants exposed to the atmosphere, except the stigma.

It usually consists of a layer or layers of compressed cells, having

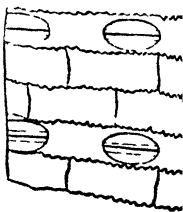


Fig. 21.



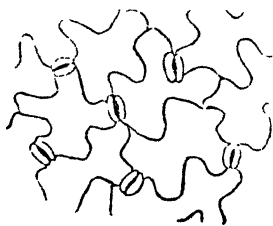
their walls bounded by waved (*Fig. 22*) or straight (*Fig. 21*) lines, and without intercellular spaces. These cells are usually colourless, and with fluid contents.

A superficial pellicle is spread over and upon the epidermis, and is considered by some as a secretion of the epidermal cells below it.

An imperfectly formed epidermis, called *Epiblema* (*epi*, Gr. upon; *blema*, a wound), supplies the place of the epidermis in submerged plants, and on the extremities of growing roots.

The name of *Epithelium* (*epi*, Gr. upon; *thēlus*, tender) has been given to a very thin cuticular covering found lining the ovary and other internal parts of the plant.

There are openings of a peculiar character between some of the cells of the epidermis, on parts exposed to the air. These are called *Stomata* (Gr. mouths).



*Fig. 22.*

They are usually formed by two semilunar cells, the ends of which unite around an oval orifice (*Fig. 22*).

The *stomata* communicate with the intercellular passages, and perform some of the functions of mouths to the plant, from their fancied resemblance

to which the name arose. They are scattered on the surface of the epidermis, sometimes with regularity, but generally without any apparent order.

*Stomata* occur on the green parts of plants, on the leaves and their appendages principally. They are not found either on cellular or aquatic plants.

On leaves they generally occupy the *under* surface

of such as are freely exposed to the air, with but few on the upper. In floating leaves the stomata occupy the *upper* surface; and on leaves which grow vertically, an equal number of stomata are found on *both* sides.

The leaves of the mistletoe have been found to possess 200 stomata to the square inch on both sides, the clove pink 38,500 on both sides, and the lilac 160,000 to the square inch on the under side and but few on the upper.

Stomata open in a moist state of the atmosphere, and close when dry.

Their functions appear to be the regulation of the transpiration, and through them the liberated gaseous bodies escape.

There are also conditions of, or appendages to, the epidermis, to which various terms are applied. It may be *naked*, *glabrous* (smooth), *silky*, *pubescent* (downy), *hairy*, *shaggy*, *velvety*, *woolly*, *glandular*, *punctated* (dotted), *scabrous* (rough), *rugose* (wrinkled), *reticulated* (netted), *verrucose* (warted), and *papillose*.

Of the appendages the most important are *Hairs*. They are composed of one or more cells, and vary much both in position and structure. Sometimes they are simple (*Fig. 23*), forked, divided, or branched, and consist of a single cell. At others they are of the same forms, and consist of various cells placed in apposition.

Several hairs, radiating from a common centre, assume a starlike or *stellate* form in the mallow tribe and *Cruciferae* (*Fig. 24*).

The hairs investing the seeds of the cotton plant are the most valuable in a commercial sense of any of the appendages of the epidermis.



Fig. 23.



Fig. 24.



Fig. 25.

Silk cotton consists of hairs from the seed-vessels of several species of *Bombax*, *Eriodendron*, *Asclepius*, &c.

*Clavate* (*clava*, a club) hairs gradually expand from the base to the apex (Fig. 25).

*Capitate* (*caput*, a head) hairs have a distinct round head (Fig. 26).



Fig. 26.

*Uncinate* (*uncus*, a hook), are hooked hairs (Fig. 27).



Fig. 27.

*Barbed* hairs have one or more hooks around the apex (Fig. 28).

*Peltate* (*pelta*, a buckler) hairs are attached at the centre (Fig. 29).

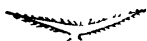


Fig. 29.

The hairs of *Drosera*, or sundew, have spiral fibres coiled in their interior.



Fig. 28.

*Prickles* are hardened hairs, and are only attached to the epidermis. *Ex. Rose.*

*Setæ* are bristles or stiff hairs.

Deciduous hairs, on falling away, often leave depressions, or openings, in the epidermis, which have been called *false stomata*.

*Glandular hairs* are such as contain secretions, either in distended cells at their apex or their base. Of this character are the receptacles of the fragrant volatile oil which gives its odour to the sweet-briar, and also the stinging hairs of the nettle (Fig. 30).



Fig. 30.

*Root-hairs* are prolongations of the superficial cells of the newest portions of roots, which they bring into close contact with the particles of soil. They die away when the epiblema is formed by the thickening of the superficial cells.

## SECTION X.

## THE DESCENDING AXIS.

From the surface of the soil the plant-axis ordinarily extends upwards and downwards; in the former direction being called the *stem*, in the latter the *root*.

As the ascending axis divides and branches, so does the descending axis, or root; but, whilst the stem produces its branches through the medium of a leaf-bud, the root is without leaf buds, neither is there a true epidermis, stomata, or a distinct pith.

The extremities of the roots are covered with loose cellular layers, termed *spongioles*.

Roots continue to grow by their extremities, which are ever removing further from the central axis and penetrating new soil, the less recent portion becoming part of the non-absorbing root, as the new extremity performs the function of absorption.

The internal structure of the root is similar to that of the stem of which it is an extension, except that the pith and medullary sheath are absent.

The point of union between the ascending and descending axis is termed the *collum*, or neck. It is sometimes marked by a distinct swelling at the base of the stem.

One class of roots consists of a simple extension of the axis downwards, which may become afterwards more or less branched. Another class consists of a number of rootlets proceeding from one point of union or attachment to the stem.

When a simple or tap root is large and succulent,

and tapers gradually towards its extremity, it is called a *conical* root (*Fig. 31*). *Ex.* Carrot.

But if it first enlarges, and afterwards diminishes, so as to become spindle-shaped (*Fig. 32*), it is termed *fusiform* (*fusus*, Lat. a spindle). *Ex.* Radish.

When a root expands still more in a lateral direction, becoming globular, or more like a boy's top (*Fig. 33*), it is *napiform* (*napus*, Lat. a turnip). *Ex.* Turnip.



Fig. 31.



Fig. 32.

If instead of a single axis there are a number of rootlets (*Fig. 34*) proceeding from, or near, a common point of attachment, and these are all threadlike in form, it is called a *fibrous* root. *Ex.* Grasses.

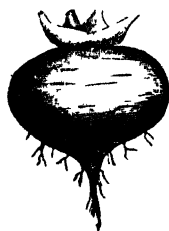


Fig.



Fig. 34.

When some of these rootlets become enlarged and succulent (*Fig. 35*), assuming an ovate form,

a *tubercular* root is formed. (This must not be confounded with similar swellings in an underground stem called *tubers*.) *Ex.* Orchis.

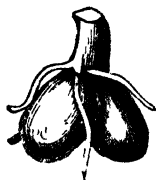


Fig. 35.

When the swellings are numerous, and succeed each other so as to present the appearance of a string of beads (*Fig. 36*), it is called a *moniliform* root (*monile*, Lat. a necklace).

If, instead of being separated, the



Fig. 36.



Fig. 38.

swellings are compressed together so as to appear as rings around the root (Fig. 37), it is *annulated* (*annulus*, Lat. a ring). *Ex.* *Ipecacuanha*.

When some of the rootlets become succulent and enlarge towards their extremities (Fig. 38), a *nodulose* root is formed (*nodus*, Lat. a knot). *Ex.* Dropwort.

When all become succulent and enlarged, so as to resemble a bundle of fusiform rootlets (Fig. 39), the root is said to be *fasciculated* (*fasciculus*, Lat. a little bundle). *Ex.* *Dahlia*.

Roots that last only one year are *annual*; if two years, *biennial*; but if longer, *perennial*.

The functions of the root consist not only in fixing the plant firmly to the earth, but also in obtaining nutriment from the soil, and often in storing up organizable matter for its support.

When two fluids of different densities are separated by a permeable medium, two currents will be established—one outwards, called *exosmose* (*exo*, Gr. outwards; *osmos*, impulsion), and one inwards, called *endosmose* (*endon*, Gr. within), which will continue



Fig. 37.



Fig. 39.

until the two fluids are of equal density. By means of such currents vegetative action is carried on. The fluid contents of roots are of greater density than the moisture of the soil; an *endosmose* current is therefore established, for which the root-hairs and the newest part of the root protected by the *spongiolæ* are the medium, accompanied also by a much smaller outward or *exosmose* current. Evaporation continually going on in the exposed portions of the plant, the contained fluids are never reduced to the density of the medium in which they grow; hence the inward current, or absorption, does not cease while the vital action is unimpaired.

*Adventitious roots* are formed in some plants for the purpose of affording additional support to the stem.

In the *ivy* they serve the office of tendrils. From the branches of the *banyan* they are produced downwards to the soil, in which they fix themselves, and develop true roots.

In the *screw-pine* and *mangrove* they are developed in a similar manner from the lower parts of the stem, and become rooted in the soil.

## SECTION XI.

### ASCENDING AXIS.—EXOGENS.

A typical plant may be characterized as consisting of *stem* and *leaves*.

The *stem* is the axis of growth, and has, ordinarily, a portion above ground, which may be considered as the *ascending axis*, and a subterranean portion, which is the *descending axis*. All branches, whether of the *ascending* or *descending axis*, are portions or offsets of the stem.

All the parts of a plant are referable to one of these typical forms, *i. e.*, stem and leaf.

The *ascending axis*, or, as commonly called, the *stem*, in its earlier stages consists almost entirely of cellular tissue. Fibrous or woody portions are afterwards developed. Some plants are entirely devoid of this axis, and consist merely of cellular expansions, called a *thallus* (*thallos*, Gr. a frond). These plants are denominated *thallogens*.

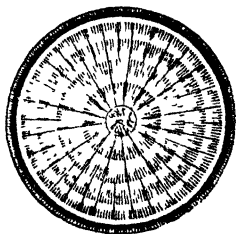
Provision is made for a regular and systematic development of leaves and branches around the axis. The points from whence leaves and buds issue are termed *nodes* (*nodus*, Lat. a knot), and the spaces between them *internodes*.

Sometimes the internodes are so much shortened that the nodes are clustered together just above the surface of the ground, and the leaves appear in the form of a rosette, and without any evident stem. *Ex.* Primrose.

The internal structure and method of increase in stems has formed the basis of a division of them into three great groups or classes, *Exogens*, *Endogens*, and *Acrogens*.

*Exogens* (*exo*, Gr. outward; *gennao*, to produce) to which class our forest trees belong, are characterized by the possession of a separable bark, wood arranged in concentric layers, the youngest at the circumference, a central pith, and medullary rays proceeding from the pith to the bark (*Fig. 40*).

The *pith*, or *medulla* (Lat. marrow), is composed of cellular tissue, the cells being



*Fig. 40*



often hexagonal. In the young plant it occupies a large proportion of the stem. In some plants it is more largely developed than in others. *Æx.* Elder.

At first the pith is greenish and succulent, but afterwards becomes pale and dry. It does not increase in growth after the first year.

The rice-paper of the Chinese and the shola pith of India are the medulla of certain plants.

*Medullary sheath.* This immediately surrounds the pith, and consists principally of spiral vessels. Prolongations from the pith pass between these vessels into, and intersect the woody layers (medullary rays).

Wood is deposited annually in layers, or circles, upon that of the previous year. A transverse section of an exogenous stem shows these concentric zones, or rings of wood, each of which is generally the produce of a single year. Hence the ages of trees have been calculated from the number of these concentric rings. In some trees the circles are marked much more distinctly than in others. The external layers are the youngest. The internal, or oldest, occasionally exhibit a distinct difference in colour. *Æx.* *Lignum vitæ*.

The concentric rings are not always developed equally all around the tree; so that the pith is not always in the centre. On that side of the stem which has, during growth, been most exposed to the light, the woody layers will be found thicker, and the entire rings of some years will give evidence of a more vigorous growth in a wider circle for that year.

*Duramen* (*durus*, Lat. hard). The interior, or *heart-wood*, called also *duramen*, from its greater hardness, is black in the ebony, and brown in coccus-wood, while the external layers of *alburnum* (*albus*, Lat. white) or *sapwood*, are pale-coloured, soft, and permeable.

*Cambium.* Between the external layers of wood and the bark, a copious semifluid mucilage is found in

the spring, to which the name of *cambium* (*cambio*, Lat. to change) has been given. Cells are afterwards formed in it, which become elongated and deposited, and originate the new layer of wood for the year.

*Medullary rays* may be seen radiating from the centre in almost any transverse section of an exogenous stem. They constitute the medium of communication between the pith and bark; and consist chiefly of flattened muriform cells. These intersections separate the wood into a series of wedges, more or less widely separated. These are sometimes very distinct. *Ex.* Clematis.

The *Bark* occupies the most external position in the plant. It consists of three layers, besides the epidermis, i. e.—

*Epiphloeum* (*epi*, Gr. upon; *phloios*, bark).

*Mesophloeum* (*mesos*, Gr. middle).

*Endophloeum* (*endon*, Gr. within), or *Liber*.

The *Epiphloeum*, outer or *suberous* layer of bark, consists of flat tabulated cells. In some instances it is very thin, and in others largely developed in a thick corky layer, which readily separates from the series below it. *Ex.* Cork oak.

The *Mesophloeum*, or middle layer, is generally developed to a less extent than the outer. It consists of cells differing in form from those of the *epiphloeum*, with thicker walls, and intercellular spaces. The laticiferous vessels occur in this series. The *mesophloeum* is occasionally much developed. *Ex.* Larch.

The *Endophloeum*, or *liber*, is the fibrous or vascular layer of the bark; it is the *bast-layer*, so useful for textile purposes. During growth it separates into a kind of network. *Ex.* Lace bark and Cuba bast.

Additions are made to the cortical layers *internally*.

The *cellular* system of the stem has been seen to

consist, in exogens, of the pith, medullary rays, and two outer layers of the bark.

Peculiar and anomalous forms occasionally occur, in which secondary woody masses surround the central or primary one.

## SECTION XII.

### ASCENDING AXIS—ENDOGENS AND ACROGENS.

*Endogens* (*endon.* Gr. within; *gennao*, to produce) include the palms and grasses, as well as other natural orders of plants. The chief features in endogens consist in the cellular and vascular systems being mixed together, or rather, in the cellular portion being traversed throughout its extent by vascular fibres. They do not possess a distinct central pith, medullary rays, concentric rings, or a separable bark. The external portion of the stem is the hardest. The name originated with the belief that the stem increased by additions at the centre, so that the materials earlier accumulated were pushed outwards. The structure of a palm stem being accepted as a type, it has been shown that the new fibres proceeding from the new leaves downwards first direct themselves to

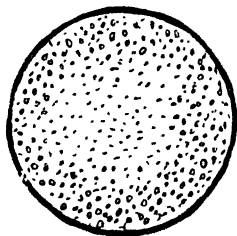


FIG. 41.

the centre, whence they soon diverge, crossing the existing fibres in their progress to the circumference, where they become at last the most external (*Fig. 42*). Exogens increase in diameter indefinitely, endogens do not thus increase beyond a certain period (*Fig. 41—42*).

At the upper portion of the

palm stem, the vascular bundles proceeding from the leaves contain spiral, porous, and laticiferous vessels, mixed with threads resembling liber. These all successively disappear, except the last, or become converted into a complete network of fibrous tissue as they reach the circumference.

In grasses the stem is often hollow from node to node, at which point the fibres cross over to opposite sides, and by interlacing form a dissepiment or partition across the stem. In the rapid growth of this kind of stem the more cellular central portion is ruptured and disappears.

Circles are sometimes visible in a transverse section of a palm stem from the upper portion, but these bear no analogy to the concentric rings of exogens.

The loose thready character of palm stems renders them almost valueless as timber trees: this is often compensated for by other valuable products.

*Acrogens* (*akron*, Gr. summit). In this instance the additions to the stem are dependent upon the union of the bases of the leaf-stalks, and the extension by growth of fresh leaves at the summit.

To this class, tree ferns belong.

Acrogens have no other stem than that formed by the union of the bases of the leaf-stalks with the axis from

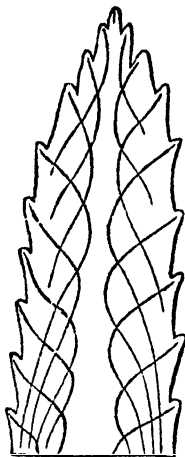


Fig 42.

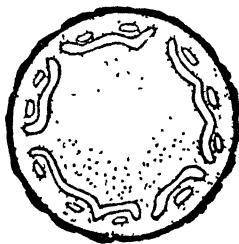


Fig 43

which they were developed. Scars are left on the surface of the stem where the upper portions of the leaves have fallen away (*Fig. 43*).

A section of a tree fern exhibits a circle of irregular vascular bundles near the circumference, which were originally each of them the vascular system of leaf-stalk. The rest of the stem is cellular, which fall away eventually in the centre, and leaves the stem hollow.

The stem of a tree fern may always be distinguished from that of an endogen by the presence of the vascular bundles, and the rhomboidal scars on the exterior.

Acrogenous stems are seldom branched or furcate.

The leaves of acrogens are denominated *fronds* (*frons, frondis*, Lat. a leaf), and the petioles, or stems, are called *stipes* (Lat. a trunk of a tree).

*Stems* are said to be *procumbent* (*procumbo*, Lat. I lie flat) when they lie on the ground.

*Scandent stems* (*scando*, Lat. I climb) are such as climb by means of suckers or tendrils.

*Voluble stems* (*volubilis*, Lat. easily turned) are those which entwine around other plants, as the hop and honeysuckle.

### SECTION XIII.

#### SUBTERRANEAN STEMS

Under the name of subterranean stems we have included also those which are prostrate and not strictly subterranean.

The majority of forms to be described in this section are popularly designated as *roots*.

It must be remembered that *roots* do not possess

scales (modified leaves) or buds (rudimentary leaves) or nodes (whence buds are developed)

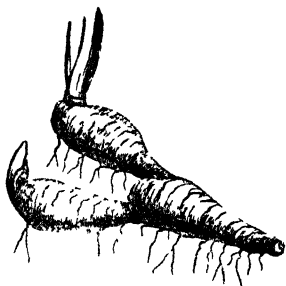
The *Rhizome* (*rhiza*, Gr. a root), or rootstock, is a thick, procumbent stem, partly, and sometimes entirely, under the surface of the soil. It develops roots from its under side, and leaves from its upper. Its surface generally bears the scars left by the falling away of old leaves (*Fig 44*).

*Ex. Iris*

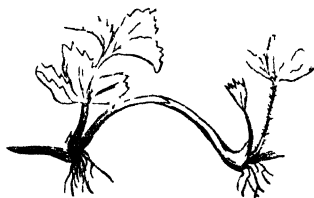
The *Flagellum* (Lat. a young twig), or runner, is a long, slender, procumbent branch, which develops a leaf-bud from its upper surface, and roots from its under, at each node. Each vegetating node becomes a perfect plant (*Fig 45*).

*Ex. Strawberry.*

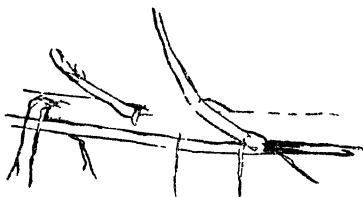
The *Soboles* (Lat. a shoot or young branch) is a creeping underground stem, or branch, which emits roots from its under surface and leaves from its upper. It thus



*Fig 44*



*Fig 45*



*Fig 46*

resembles a rhizome, but is much more slender, and subterranean in its character (*Fig. 46*). *Ex.* Couch grass.



The *Tuber* (Lat. a knob) is a thickened portion of an underground stem or branch, which serves as a depository for starch, and other nutritious secretions for the service of the plant (*Fig. 47*). *Ex.* Potato

A scaly modification of the tuber exists in the species of *Maranta* which yields arrowroot

*Bulbs* are scaly modifications of leaf buds developed upon a flattish disk, from the under surface of which roots are directed downwards (*Fig. 48*). *Ex.* Onion



*Fig. 48*

The *Pseudo bulbs* of orchids are thickenings of the base of the stem by the deposit of basome; they are produced above the surface, and are of a green colour.

*Corms* (*kormos* Gr a stem) are also expansions of the base of the stem,

differing from bulbs in being solid and not scaly, and from pseudo bulbs in being subterranean, and consequently not green. Corms also contain starch and other nutritious secretions. Some botanists consider them as buds (*Fig. 49*). *Ex.* Meadow saffron.

*Bulbs*, *pseudo-bulbs*, and *corms* are confined to endogenous plants.



*Fig. 49*

## SECTION XIV.

## LEAF-BUDS.

Leaf-buds are either axillary or terminal, *i. e.*, they constitute the extremity or growing point of branches, or are produced in the *axils* of previously developed leaves.

Because of their capability of being removed and engrafted or budded upon other plants, they have been called *fixed embryos*.

They are generally protected by scales of a firmer texture than the leaves themselves, which serve a temporary purpose, and then fall away.

These scales are lapped over each other, in accordance with a spiral arrangement, so that the bud resembles a small cone.

The arrangement of leaves in the bud is termed *vernation* (*ver*, Lat. spring), and follows different plans in different plants, according to regular fixed laws.

The following are the most common forms of *vernation*. First, of individual leaves.

*Reclinate* (*reclino*, Lat. I bend back), folded down from the apex to the base (*Fig. 50*). *Ex.* Liriodendron.

*Circinate* (*circino*, Lat. I turn round), rolled from apex to base, as in the fronds of ferns (*Fig. 51*).

*Conduplicate* (*conduplico*, I double), folded laterally (*Fig. 52*). *Ex.* Oak.

*Plicate* (Lat. knit together), several folds like a fan (*Fig. 53*). *Ex.* Vine.

*Convolute* (*convolvo*, Lat. I entwine), rolled upon itself (*Fig. 54*). *Ex.* Apricot.



Fig. 50.



Fig. 51.



Fig. 52.



Fig. 53.





*Involute* (*involvere*, Lat. I fold in), with the edges rolled inwards (*Fig. 55*). *Ex.* Violet.

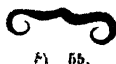


Fig. 55.

Fig. 54.

*Revolute* (*revolvere*, Lat. I roll back), with the edges rolled outwards (*Fig. 56*). *Ex.* Rosemary.



Fig. 56.

The arrangement of all the leaves in the bud gives rise to other names.



Fig. 57.

*Valvate* (*valve*, Lat. folding-doors), nearly in a circle, at the same level touching each other by the edges (*Fig. 57*).



Fig. 59.

*Imbricated* (*imbricare*, Lat. a roof-tile), applied over each other at different levels, as the tiles of a house (*Fig. 58*). *Ex.* Lilac.



Fig. 58.

*Twisted or spiral*. When the margin of one leaf overlaps that of another (*Fig. 59*).

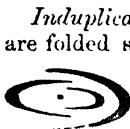


Fig. 61.

*Induplicate* (Lat. folded in). The leaves are folded so as to touch at their edges, or the margins are folded inwards (*Fig. 60*).



Fig. 60

*Equantant* (*equito*, Lat. I

ride), conduplicate leaves covering each other in opposition (*Fig. 61*). *Ex.* Privet.



Fig. 62.

*Obvolvate* (*obvolvere*, Lat. I wrap round). Half of one leaf covers half of another, so that it becomes half-equantant (*Fig. 62*).

*Ex.* Sage.

The bud is often protected by a resinous exudation or a downy covering.

*Bulbs* (see *Fig. 49*) are subterranean buds, in the centre of which is a growing point covered with scales. New bulbs are formed like buds in the axils of the scales.

*Bulbils* are small rounded bodies resembling bulbs,

consisting of a number of thickened scales, frequently consolidated together. They are found in the axils of the leaves of some lilies, are easily detached, and capable of producing young plants under favourable circumstances.

*Adventitious buds* in the form of woody nodules are found in the bark of some trees, and are called by Dutrochet embryo-buds, but more appropriately by Dr. Lankester, abortive branches. *Ex.* Cedar.

Leaf-buds may become arrested and transformed into *spines*, or thorns, as in the sloe and barberry.

Under other conditions, leaf-buds may be converted into *tendrils*, as in the passion-flower.



Fig 63

Branches are but lateral expansions of the stem, or developed leaf-buds proceeding from the cellular system of the stem; branches of the first year, directly from the pith and medullary sheath (*Fig. 63 a*), and those developed afterwards communi-

cating through the medullary rays (*Fig. 63 b*) with the central medulla.

## SECTION XV.

### LEAF-STRUCTURE.

Leaves are appendages to the stems of plants, and may be regarded as expansions of the bark.

A leaf generally consists of an expanded portion, called the *blade* or *limb*, and a stalk or *petiole*, which latter sometimes expands at the base into a *sheath* or *vagina* embracing the stem, or becomes developed into leaflets called *stipules*.

Leaves consist of vascular tissue in the *veins* or *ribs*, with cellular tissue, or *parenchyma*, filling up the interstices, and an *epidermis* covering all. In what are called skeleton leaves, the cellular portion is removed by maceration, and the network of the fibro-vascular remains. The lattice-leaf plant of Madagascar has skeleton leaves with very little *parenchyma*.

The *Epidermis* (*epi*, Gr. upon; *derma*, skin) consists of more or less compressed cells, having a different structure on the upper and under side of the leaf. The cells of the epidermis are generally flat, with sinuous, wavy, and irregular margins fitting in to each other, and leaving no openings or intercellular spaces, excepting *stomata*.



Fig. 64

These latter orifices occur principally in the epidermis of the under surface of aerial leaves, and the upper surface of floating leaves (*Fig. 64 s s*). The cells of the epidermis are transparent and colourless.

The *Parenchyma* is the cellular tissue of the leaf which fills up the interstices between the veins. It consists of two series of cells, each containing chlorophyll. Below the upper epidermis of the leaf the cells are arranged more closely together, perpendicularly to the surface, and with very small spaces between them. The cells beneath are arranged horizontally, are more irregular, with larger intercellular spaces. This arrangement varies in different plants; in some, where both sides of the leaf are equally exposed to the light, the cellular series are similar on both sides.

*Submerged leaves* have no true epidermis, no fibro-vascular system, and no stomata. They consist of closely-compacted cells on the surface, which become

elongated and compressed so as to resemble veins. The internal cells are very irregularly disposed, with large intercellular spaces containing air, which serve to support the leaf.

The *vascular system* of leaves is also double. On the upper side there are spiral vessels, reticulated or porous vessels, and woody fibre, and on the under side laticiferous vessels and fibres. These ramify through the leaf in the form of either simple or branching veins. This vascular system is a continuation of that of the stem, the upper corresponds to the woody layers, and the under to the *liber*, or *endophloëum*.

The *venation*, or distribution of the veins of leaves, varies in different plants.

In thick or *succulent* leaves they cannot be distinguished, on account of the mass of cellular tissue in which they are imbedded.

In the lower orders of plants, such as lichens and sea-weeds, and in submerged leaves, they are absent altogether.

In an ordinary leaf, as in that of the oak, there is a central continuation of the petiole, or footstalk, which is larger than the other veins. This is called the *midrib*; it gives off other veins from either side, which are called *primary*, and if these give rise again to others, they are called *secondary*, &c. Leaves of this kind, with one large rib, are called *unicostate* (*unus*, Lat. one; *costa*, rib).

In such leaves as those of the sycamore, in the place of one central rib, there are two or more diverging from the point of junction of the blade with the petiole. These are *multicostate* (Lat. many-ribbed).

In all these instances there is a complete network of veins produced; hence the term *reticulated* (*reticulum*, Lat. a net), or *net-veined*, has been applied (*Fig. 65*).



Fig 65

to the apex of the leaf in a straight or nearly straight direction as in the plantain and banana of the tropics. In both cases there is generally small venlets uniting the veins together, but they do not form a regular network and



Fig 67

In some instances the veins end in curvatures within the margin of the leaf in others the veins proceed directly to the margin as in the oak. The latter, for the sake of distinction have been termed *feather veined*.

In plants of a certain kind of which grasses may be taken as a familiar example there is a midrib and veins running parallel to it from the base to the apex of the leaf (Fig

66) or in other and less familiar instances there exists a central midrib

with veins running from it to the margin of the leaf in a straight or nearly straight direction as in the plantain and banana of the tropics. In both cases there is generally small venlets uniting the veins together, but they do not form a regular network and are insufficient to prevent the leaf being torn down in strips between every pair of veins.

These are instances of *parallel veined leaves*.



Fig 66

In the leaves of ferns a third kind of venation is distinguishable in which the veins divide in a forked manner. This kind of venation is therefore termed *furcate* (*furca*, Lat a fork) (Fig 67).

As a general rule, exogenous plants are possessed of leaves with a reticulated or netted venation, endogenous plants of leaves with a parallel venation and acrogens of furcate veined leaves.

## SECTION XVI.

## LEAF-FORM.

Many distinctive features are imparted to leaves by the relative development of their vascular or cellular tissue. When the vascular increases most rapidly, and the parenchyma is insufficient to occupy the intermediate spaces, the leaf becomes deeply divided; sometimes the parenchyma is reduced to mere threads along each side of the principal veins. This feature is exhibited by the leaves of the horseradish when grown in sand or very poor soil. The vascular tissue may be prolonged beyond the margin of the leaf, terminating in spines, as in the holly. Under favourable circumstances, the cellular portion is most developed, so that the spaces between the veins of the leaf are too small to allow of its lying level between them; in this case it forms prominences, giving to the leaf a curled, crumpled, or corrugated appearance, as in the Savoy cabbage.

The innumerable forms of leaves may be well enough characterized for ordinary purposes by a few prominent types.

They are *simple*, when the blade is undivided, or when the divisions do not proceed directly to the midrib.

When these conditions are not fulfilled, the leaf is said to be *compound*.

*Simple leaves*, when undivided, are—

ACICULAR (needle shaped), when long and filament-like, as in firs.

SUBULATE (awl-shaped) when narrow and tapering from base to apex, as in the yew (*Fig. 68*)



FIG. 68.

- LINEAR, when long and narrow (*Fig 69*), but of equal width throughout.
- LANCEOLATE, shaped like a lance-head (*Fig. 70*).
- OVATE, egg-shaped, broadest towards the base (*Fig. 71*).
- OBVATE is reversely ovate, broadest at the apex (*Fig. 72*).
- OVAL, or *elliptical*, widest in the middle (*Fig 73*).
- ORBICULAR, or round (*Fig. 74*). This form of leaf is generally *peltate*.

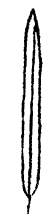


Fig. 69

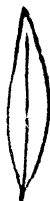


Fig. 70



Fig. 71.



Fig. 72

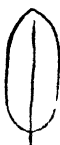


Fig. 73

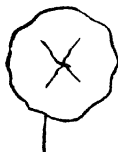


Fig. 74



Fig. 75

RENIFORM, or kidney shaped (*Fig. 75*)

CORDATE, heart shaped (*Fig. 76*)

OBCORDATE, reversely heart-shaped (*Fig. 77*).



Fig. 76

SAGITTATE (*sagitta*, Lat. an arrow), shaped like an arrow-head (*Fig. 78*)

SPATHULATE (*spatula*, Lat. a kind of spoon), resembling a spoon (*Fig. 79*).



Fig. 77.



Fig. 78



Fig. 79

# STRUCTURAL BOTANY.



Fig. 80.

**PANDURIFORM** (*pandatus*, Lat. bent in the middle), somewhat of the form of a fiddle (*Fig. 80*).

Simple leaves, when divided, may be—

**BILOBATE**, or two-lobed.

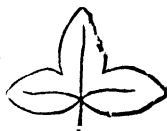


Fig. 81.

**TRILOBATE**, or three-lobed (*Fig. 81*).



Fig. 83.

**HASTATE**, halberd-shaped (*Fig. 82*).

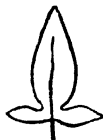


Fig. 82.

**QUINQUANGULAR**, five-angled (*Fig. 83*).

**PALMATE**, with five lobes, resembling a hand (*Fig. 84*).

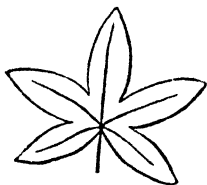


Fig. 84.

**PEDATE** (*pes*, Lat. a foot), from a supposed resemblance to the foot of a bird (*Fig. 85*). *Ex. Hellebore.*



Fig. 85.

A leaf is said to be *compound* when

it is divided down to the midrib, so that the subdivisions appear as distinct leaves, which are called, in such instances, *leaflets*.

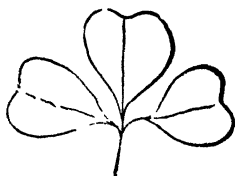


Fig. 86

**TERNATE**, when composed of three leaflets (*Fig. 86*).

When this division is repeated upon itself, the leaf is *biter-nate*; and when again repeated, *triternate*.

**DIGITATE** (*digitus*, Lat. a finger), when there are five leaflets, like the fingers of a hand (*Fig. 87*).





Fig. 8

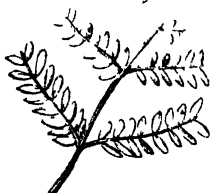


Fig. 9



Fig. 10



Fig. 11

stem, it is *amplexicaul* (*amplexus*, Lat. embracing, *caulis*, stem) (Fig. 91).

When it runs along and is united to the stem, as a winged appendage, it is *decurrens* (*decurreo*, Lat. I run along) (Fig. 92). *Ex* Thistle

**PINNATE** (*pinnatus*, Lat. a feather) when the leaflets are arranged along the sides of the petiole (Fig. 88). They may be *oppositely* or *alternately* pinnate.

When each leaflet is again divided in a pinnate manner, the leaf is *bipinnate* (Fig. 89) and when again subdivided *tripinnate* (Fig. 90). When not referable to any one of these forms by a more complicated subdivision the leaf is said to be *uprâ decomposita*.

The venation of compound leaves agrees with that of simple leaves, the compound character resulting from deficient parenchyma.

When the base of the leaf embraces the



Fig. 12



Fig. 93.

When the bases of two leaves unite, they are *connate* (Fig. 93). *Ex.* Teasel.

The margins of leaves also present distinctive features. When smooth or without serratures, they are *entire*.

**SERRATE** (*serra*, Lat. a saw), when indented like a saw (Fig. 94).

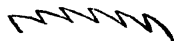


Fig. 94.

**BISERRATE**, when each of such indentations is again similarly indented (Fig. 95).

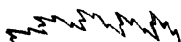


Fig. 95.

**RUNCINATE** (*runcina*, Lat. a large saw), toothed like a pit-saw (Fig. 96).



Fig. 96.

**CRENATE**, with convex serratures (Fig. 97).



Fig. 97.

**DENTATE** (*dens*, Lat. a tooth), with concave serratures (Fig. 98).



Fig. 98.

**ACUTELY CRENATE**, when the serratures are rectangular (Fig. 99).



Fig. 99.

**CILIATED** (*cilium*, Lat. an eye-lash), when fringed with hairs (Fig. 100).

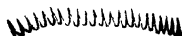


Fig. 100.

**SINUATE**, or waved; often irregularly (Fig. 101).



Fig. 101.

## SECTION XVII.

### LEAF-ORDER.

Leaves are arranged symmetrically about the stem; this is called *Leaf-order*, or *Phyllotaxis* (*phyllon*, Gr. a leaf, *taxis* order). There are regular nodes at

which leaves are developed, in accordance with a definite plan.

Each node is capable of developing a leaf, and when the arrangement is such as to produce single leaves at different levels on the axis, the leaves are then said to be *alternate*. *Ex.* Lime.

When some of the internodes are shortened, so as to bring two leaves to the same level at opposite sides of the axis, they are called *opposite*. *Ex.* Lilac.

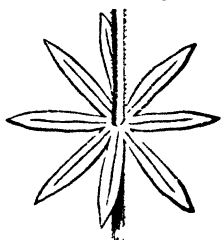


Fig. 102.

If more than two leaves are developed at the same level, they are said to be *verticillate*; and the leaves thus arranged constitute a *verticel* (*certo*, Lat. 1 turn), or *whorl* (Fig. 102). *Ex.* Goosegrass.

When pairs of opposite leaves cross at right angles, so that the first and third, and second and fourth pair are perpendicular to each other, they are *decussate* (*decusso*, Lat. 1 cut across). *Ex.* Dead-nettle.

Alternate leaves are arranged in varied order in different species of plants. When they form two rows on opposite sides of the stem, so that the third leaf is over the first, the arrangement is *distichous* (*dis*, Gr. twice; *stichos*, rank).

The *spiral* may be accepted as typical of leaf-order, and the different arrangements may be represented by fractions, in which the numerator shall represent the number of turns in the spiral, and the denominator the number of leaves encountered in a spiral proceeding right or left from any given leaf to the next one immediately above it.

Thus  $\frac{1}{2}$  represents the *distichous* arrangement; two leaves being encountered in one turn of the spiral, the third being over the first. *Ex.* Lime.

And  $\frac{1}{3}$  the *tristichous*. *Ex.* Sedge.

$\frac{2}{5}$  represents the *tetrastichous*. In this instance two turns of the spiral must be traversed before a leaf is encountered, which is directly over the first, and which, in this instance, is the sixth. *Ex.* Oak.

$\frac{3}{8}$  is another common arrangement. *Ex.* Laurel.

$\frac{4}{13}$  is found exemplified in the Houseleek.

$\frac{5}{11}$  in the lanceolate Plantain.

$\frac{1}{3} \frac{2}{4}$  in another species of Plantain (*Plantago media*), and other plants.

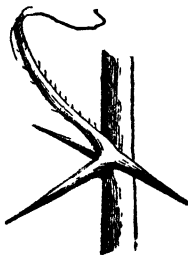
In some instances a certain number of leaves are *fascicled*, or collected in a bundle, surrounded by a sheath at the base. *Ex.* Fir.

A theory has been propounded, based on accidental coincidences, that the angles at which the primary veins of the leaf diverge from the mid-rib, the principal branches from the stem and those from the root coincide; but the facts do not appear to us to be proven.

## SECTION XVIII.

### LEAF-APPENDAGES.

The *petiole* (*petiolus*, Lat. a stalk), or stalk of a leaf, forms an articulation, more or less complete, at the point of union with the stem. In some instances a transverse articulation takes place, as in the orange. The cushion-like swelling sometimes occurring at the base is called a *pulvinus* (Lat. a cushion); in the gooseberry it is changed into spines (*Fig.* 103).



*Fig.* 103.

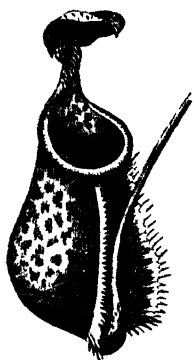


Fig. 104.

When a petiole becomes developed in a leaf-like manner, the lamina being abortive, or nearly so, it is termed a *phyllodium* (*phyllon*, Gr. a leaf). *Ex.* some *Acacias*.

Occasionally, the petiole not only becomes leaf-like, but the margins are folded in so as to form a kind of urn or pitcher, called an *ascidium* (*askidion*, Gr. a small leather bottle), if closed, and an *ampulla* (Lat. an open vessel), if open (*Fig. 104*). *Ex.* Pitcher-plant.

When the lamina is abortive, the petiole may become transformed into a *tendrill*, or when a lamina is present, the petiole may be extended beyond it in a tendrill-like manner. The upper leaflets of a pinnate leaf are also sometimes converted into *tendrils*.

On either side of the petiole, at its base, expansions and modifications occur, which are denominated *stipules* (Lat. a straw).

These are extremely variable in form and appearance (*Fig. 105 s*).

When they embrace the stem, so as to inclose it in a kind of sheath, such form of stipule is called an *ochrea* (Lat. a boot). *Ex.* *Rhubarb*.

When they resemble leaves in appearance, they are said to be *foliaceous*. In some instances they are very large and foliaceous. *Ex.* *Pea*.



Fig. 106.



Fig. 106.

They may occur between the bases of the petioles of opposite leaves, and are then described as *interpetiolarly* (*Fig. 106 s*). *Ex. Cinchona.*

If the stipules are attached through their entire length on either side of the petiole, they are *adnate*. *Ex. Rose.*

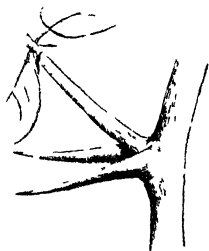
The fibrous material found at the base of palm-leaves is often considered as of a stipulate character, and is termed a *reticulum* (Lat. a net).

The sheathing petiole of grasses is of an allied character, and is called a *vagina*.

Stipules are sometimes converted into tendrils. *Ex. Smilax sp.*

Or they may be consolidated into thorns (*Fig. 107*) *Ex. Acacia.*

Regard must be paid more to their position than appearance, on account of their varied modifications



*Fig. 107.*

When the leaflets of a compound leaf have at their bases small appendages of a similar character, these are called *stipels*. *Ex. Bean.*

Leaves having stipules are described as *stipulate*, but when absent, *exstipulate*.

## SECTION XIX.

### FLOWER-BUD

Flowers in the bud may be described as **fixed points surrounded by rudimentary modified leaves.** They differ from **leaf-buds** in the **central point** being

fixed instead of growing. Sometimes this central point departs from its fixed character, and, by continuing its growth, assumes the form of a branch, with leaves but little differing from the ordinary leaves of the plant. Such a growth is an unnatural one, and is generally characterized as a monstrosity.

Flower-buds proceed from the axils of leaves. Such leaves are termed *floral leaves*, or *bracts* (*bractea*, Lat. a thin leaf).

Sometimes these bracts are coloured, as in *Bougainvillea*; at others they remain green, as in the Lime.

All intermediate leaves, of whatever size, form, or colour, intervening between the bract and the calyx, are called *bractlets*.

A single bract may become so enlarged and folded as to inclose many flowers, which are arranged on a *spadix*. Such form of bract is termed a *spathe*. It is either membranaceous, foliaceous, or woody (Fig. 108). *Lx Arum*.

If several bracts are arranged in a *whorl* or *verticel* around the base of certain kinds of inflorescence, such as an umbel or capitulum, such a verticel of bracts is called an *involucre*. *Ec.* Fool's parsley.

Small bracts which overlap, or imbricate, like the tiles of a house, are often termed *scales*. When the bracts of an involucre cohere and form a cup around the base of the fruit, as in the acorn, it is called a *cupule* (*cupula*, Lat. a little cup (Fig. 109)

The manner in which the *floral en-*



Fig 108

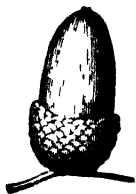


Fig. 109.

*velopes*, i. e., the calyx and corolla, are arranged in the bud, is termed *æstivation* (*æstivus*, Lat. belonging to summer).

This arrangement often differs from that of leaf-buds considerably, and is commonly of one of the following kinds:—



Fig. 111.

**VALVATE.** This is the same as valvate vernation in leaf-buds (*Fig. 110*).

**IMDUPLICATE.** When the margins are folded inwards (*Fig. 111*).



Fig. 110.



Fig. 112

**CONTORTED, or TWISTED.** When twisted in the bud (*Fig. 112*).

**IMBRICATE.** When overlapping, as in the tiles of a house (*Fig. 113*).



Fig. 113



Fig. 114

**QUINCUNCIAL** (*quincunx*. Lat. arranged as five in cards). Five sepals or petals, arranged in a spiral, so that two are exterior, two interior, and one half exterior and half interior (*Fig. 114*).



Fig. 114



Fig. 117.

**ALTERNATE.** When the inner whorl alternates with the outer (*Fig. 115*).

**PLICATIVE.** When folded or plaited together (*Fig. 116*).



Fig. 116

**VEXILLARY** (*vexillum*, Lat. a standard). A common form of *æstivation* in papilionaceous plants, where *v* is the vexillum, *a* the alæ, and *c* the carina (*Fig. 117*).

The different forms of *æstivation* are each perma-



nent in the species in which they are found, and are of some importance in systematic botany.

## SECTION XX.

## INFLORESCENCE.

The arrangement of flowers on the axis of growth is called the *Inflorescence* or *Anthotaxis* (*anthos*, Gr. a flower; *taxis*, order).

The axis, or primary stem supporting a flowering head, is termed the *rachis* (*rachis*, Gr. a backbone). The stalk supporting a flower is a *peduncle* (*pes*, Lat. a foot); and if this is branched, then the small branches which it gives off are *pedicels*.

A flower having no stalk is said to be *sessile*; but if stalked, *pedicellate*.

The following are the most common forms of inflorescence:—

**SPIKE.** When the peduncles are very short or wanting altogether (*Fig 118*). *Ex. Plantago Amentum* or *catkin*, a *deciduous* spike, bearing unisexual flowers. *Ex. Willow.*

*Spadix*, a *succulent* spike, surrounded by a sheathing bract or *spathe* (*Fig. 118*). *Ex. Arum.*

*Strobilus* (Gr. a fir cone), a dense spike of female flowers, covered with membranaceous scales. *Ex Hop.*



Fig 118

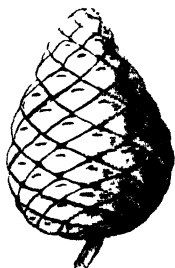
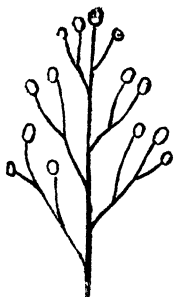


Fig 119.

**Cone**, a dense spike of female flowers covered with woody scales (*Fig. 119*).

*Ex. Fir.*

**Locusta**, a spikelet or flower-cluster of grasses.



*Fig. 121.*

**RACEME** (*racemus*, Lat. a bunch) differs from a spike, in the flowers being supported upon pedicels of equal length (*Fig. 120*). *Ex. Ribes.*

**PANICLE** (*panicula*, Lat. down of reeds) is a compound raceme, or a raceme with branched pedicels (*Fig. 121*). *Ex. Poa.*

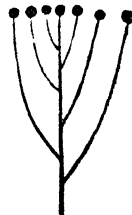
*Thyrus* (*thyrus*, Gr. a



*Fig. 120*

*Bacchanal's wand*) is a compact panicle in which the pedicels are short and often thickened, or succulent. Some botanists characterize it as a panicle having the middle peduncles longer than those above and below them *Ex. Lilac and Horse-chestnut.*

**CORYMB** (*corymbus*, Lat. summit), a kind of raceme, in which the pedicels are gradually elongated, from the apex downwards, so that all the flowers are brought to the same level, or nearly so (*Fig. 122*). *Ex. Cerasus.*



*Fig. 122.*

When these pedicels are at the same time branched, it is called a *compound corymb*.

**CYME** (*kuma*, Gr. a wave) is a panicle with the pedicels so developed or arrested, that the flowers



Fig. 123.

are brought to nearly the same level as in an umbel (Fig. 123, 124). *Ex.* Elder



Fig. 124.

This kind of inflorescence should be studied rather in its development than its form. The order of expansion is *centrifugal*.

When the basal flowers expand first, the order of expansion is *centripetal* (*centrum*, Lat. centre; *peto*, I seek).

When the central, or uppermost flowers expand first, it is *centrifugal* (*centrum*, Lat. centre; *fugo*, I fly).

**CAPITULUM** (*caput*, Lat. a head).

When numerous flowers are arranged upon a nearly flat disk or receptacle (Fig. 125).

*Ex.* Daisy.



Fig. 125.

**Glomerulus** (like a ball). When the *capitulum* assumes a globular form (Fig. 126).

*Ex.* Teasel

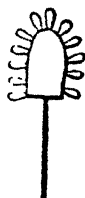


Fig. 126

**Hypanthodium** (*upo*, Gr. under; *anthos*, a flower) When the receptacle folds upwards, so as partially or entirely to inclose the flowers (Fig. 127). *Ex.* Fig

**UMBEL** (*umbella*, Lat. a sun-shade)

When all the flowers are supported upon pedicels of equal length which arise from a common point, and

spread out like radii (Fig. 128). *Ex.* Ivy.



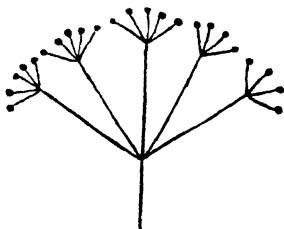
Fig. 128

If each of the pedicels of an umbel gives rise to a secondary umbel, the entire inflorescence is

termed a compound umbel (*Fig. 129*). *Ex.* Carrot, &c.

Most of these forms, by repetition upon themselves, become *compound*.

The pedicels are but branches, and the various forms and developments of these flower-branches only modifications of the stem.



*Fig. 129.*

## SECTION XXI.

### THE CALYX.

The flower and its appendages consist ordinarily of four whorls of modified leaves; the outer two constituting the *floral envelopes*, and the inner two the *essential organs*.

The exterior whorl of the floral envelopes is the *calyx* (Gr. a cup). It consists of modifications of leaves, called *sepals* (*sepio*, Lat. I inclose), either united in part, or altogether or entirely free. When the *sepals* are free, the calyx is said to be *polysepalous* (*polus*, Gr. many); and when united, *gamosepalous* (*gamos*, Gr. union), or monosepalous (*monos*, Gr. one). These sepals present all the characters of leaves, and are sometimes, in cases of monstrosity, converted into ordinary leaves. They may be green, as in the rose, or coloured, as in the fuchsia. When green they are *foliaceous* (leaf-like), and when coloured, *petaloid* (petal-like). The external envelope of the flower is always considered the calyx.

In some instances the flower appears to have a

double calyx, the outer being called the *epicalyx* (*epi*, Gr. upon). *Ex.* Mallow.

In a monosepalous calyx, the part formed by the union of the sepals is termed the *tube* of the calyx, and the free portion the *limb*.

Occasionally the calyx is *globular*, *campanulate* (bell shaped), *turbinate* (top-shaped), or *inflated*.



Fig 130

When certain parts are enlarged and prolonged into a kind of spur, the calyx is *spurred*, or *calcarate* (*Fig 130*). *Ex.* *Tropaeolum*.

In composite plants the calyx is adherent to the ovary, and



the limb becomes developed into a *pappus* (Lat. thistle-down) or hairy crown, by means of which the fruit when ripe, is transported through the air (*Fig 131*). *Ex.* Dandelion.

In the bright yellow *Eschscholtzia*, the upper portion of the calyx is ruptured from the lower, and curved upon the expanding corolla, leaving a permanent ring or fringe at the base. This form of calyx is termed *operculate* (*operculum*, Lat. a lid) or *calyptrate* (*calyptra*, Gr. a covering) (*Fig 132*).



Fig 132.

When the calyx adheres to the ovary, it is said to be *adherent* or *superior*, but when free from the ovary, it is *non-adherent*, or *inferior*.

Plants that are entirely destitute of floral envelopes are *achlamydeous* (*a*, Gr. without; *chlamys*, a tunic). *Ex.* Willows.

When but one floral envelope is present, they

are *monochlamydeous* (*monos*, Gr. one). *Ex.* *Meze-  
rium*.

When both floral envelopes are present, *dichlamy-  
deous* (*dis*, Gr. twice). *Ex.* *Geranium*.

## SECTION XXII.

## THE COROLLA.

The inner whorl of floral envelopes is termed the *corolla* (Lat. a little crown), and consists of more or less coloured leaves, and is generally the showy portion of the flower. The corolline leaves are termed *petals* (*petalon*, Gr. a leaf), and are generally placed alternately with the sepals of the calyx.

When the petals are more or less united they form a *monopetalous* corolla; and when distinct, a *polypetalous* corolla. Petals are less leaf like than sepals.

In endogens, the calyx and corolla are often similar in size, shape, and colour, hence the entire floral envelope is, in such instances, usually termed a *perianth* (*peri*, Gr. around; *anthos*, a flower) *Ex.* *Tulip*.

*Petals* are sometimes sessile, at others, the base is prolonged into an *unguis* or *claw*, when the petal is said to be *unguiculate*, and the upper or free portion is called the *lamina* or *limb* (*Fig.* 133). *Ex.* *Pink*.

The margins of petals, like those of true leaves, are either entire or toothed. When the teeth form a fringe round the margin, the petal becomes *fimbriated* (*fimbria*, Lat. a fringe). *Ex.* *Pink*.

Or a petal may be concave or hollowed like a boat, and is *navicular* (*navis*, Lat. a ship).

In other instances, one or more of the petals are



Fig 133.

prolonged into a spur, and are called *calcarate* (*calcar*, Lat. a spur). *Ex.* Columbine.

The forms of petals are described generally by the same terms as simple leaves.

When all the petals in a flower are equal in size and shape, such a flower is said to be *regular*, and when otherwise, *irregular*.

We have, therefore,—

*Regular monopetalous corolla.* *Ex.* Bluebell.

*Irregular monopetalous corolla.* *Ex.* Calceolaria.

*Regular polypetalous corolla.* *Ex.* Buttercup.

*Irregular polypetalous corolla.* *Ex.* Pea.

Of the *regular monopetalous corolla* there are varieties of form, some of the more general of which have received distinct names; as—



Fig. 134.

CAMPANULATE, or bell-shaped (*campanula*, Lat. a little bell) (*Fig.* 134). *Ex.* *Campanula*.

INFUNDIBULIFORM, or funnel-shaped (*infundibulum*, Lat. a funnel).

In this variety the corolla assumes the shape of an inverted cone (*Fig.* 135). *Ex.* Con-



Fig. 135.

volvulus



Fig. 136

HYPOCRATERIFORM, or *salver* shaped (*krater*, Gr. a cup), when the corolla consists of a straight tube surmounted by flat and spreading limbs (*Fig.* 136). *Ex.* Primrose.

TUBULAR, when it consists of a long cylindrical tube, as in the central florets of a daisy (*Fig.* 137)



Fig. 137

**ROTATE**, or wheel-shaped (*rota*, Lat. a wheel), when the tube is very short and the limbs are spreading (*Fig. 138*).

*Ex.* Forget-me-not.



*Fig. 138.*



*Fig. 139.*

**URCEOLATE**, or urn-shaped (*urceolus*, Lat. a little pitcher), when the tube narrows at both ends and expands in the middle, as in some kinds of heath (*Erica*) (*Fig. 139*).

*Irregular monopetalous corollas.*

**LABIATE**, or lipped (*labium*, Lat. a lip), when the limb has two divisions opposed to each other, with a fancied resemblance to lips. *Ex.* Ground ivy.

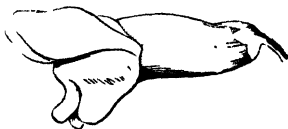
**RINGENT** (*ringor*, Lat. to grin), when the lips are widely separated, and the upper is much arched (*Fig. 140*).

*Ex.* Dead-nettle.



*Fig. 140*

**PERSONATE**, or masked (*persona*, Lat. a mask), when the lips are closed, so that there is only a chink between them (*Fig. 141*). *Ex.* Snap-dragon.



*Fig. 141.*

**CALCEOLATE** (*calceolus*, Lat. a slipper), when the lips are hollowed out into a slipper-like form (*Fig. 142*). *Ex.* Calceolaria.



*Fig. 142.*



*Fig. 143.*

**LIGULATE** (*ligula*, Lat. a little tongue), when, as in the florets of many of the composite plants, the tube ends in a strap-shaped process on one side (*Fig. 143*). *Ex.* Dandelion.



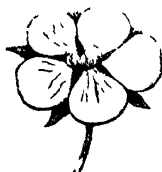
*Regular polypetalous corollas.*

Fig. 144.

ROSACEOUS, when, as in the rose tribe, there are five spreading petals without claws (*Fig. 144*). *Ex.* Strawberry.

CARYOPHYLLACEOUS, when, as in the pink tribe (*caryophyllaceæ*) there are five petals with long narrow claws, and spaces between them *Ex.* Stitchwort

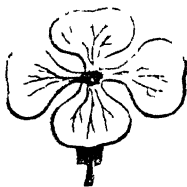


Fig. 145.

CRUCEIFORM (*cruce.* Lat. a cross), when, as in cross-works (*cruciferae*), there are four petals arranged in the form of a cross (*Fig. 145*). *Ex.* Wall-flower.

*Irregular polypetalous corolla.*

PAPILIONACEOUS (*papilio*, Lat. a butterfly), when there are five petals arranged as in the pea tribe; one superior, called the *vexillum* or standard (*Fig. 146, v*); two lateral, called *alæ* or wings (*Fig. 146, a*); two inferior, often partially united and called the *carina* or keel (*Fig. 146, c*). *Ex.* Broom.

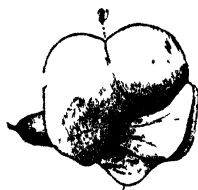


Fig. 146.

What is ordinarily termed the *disk* is an enlargement of the receptacle, either as a cup, flat disk, or cushion beneath or around the base of the ovary, and sometimes between the stamens and petals, or with one or both of these organs inserted upon it. When the disk is lobed or divided, the parts are often denominated *glands*; they should rather be considered as *abortive stamens*.

**NECTARIES.**—This term is confined to certain cavities, sometimes found at the base of petals, which secrete honey. Formerly the term was vaguely applied to other parts of the flower, but, except with the above limitation, may now be considered as obsolete. *Ex.* *Ranunculus*.

## SECTION XXIII.

## STAMENS.

The two inner whorls of the flower, called the *essential organs*, consist of stamens and pistil.

In some instances the stamens are present in one flower and the pistil in another. Such plants are said to be *diclinous* (*dis*, Gr. twice ; *klinē*, bed).

When both stamiferous and pistilliferous flowers are found on the same plant, it is said to be *monœcious* (*monos*, Gr. one ; *ekion*, habitation). *Ex.* Hazel.

When the male and female flowers are found on different plants, the term *diœcious* (*dis*, Gr. twice) is applied. *Ex.* Hemp.

The stamens, or male organs, are represented, for brevity in writing, by the following sign ♂.

The pistil, or female organ by the sign ♀.

The name *hermaphrodite* is applied to flowers in which both these organs are present, and the sign ♂ ♀ a combination of the two, is employed.

As the petals of the corolla are generally alternate with the sepals of the calyx, so the stamens are usually alternate with the petals, and consequently opposite to the sepals.

When the stamens are so placed as to spring apparently from beneath the pistil (*Fig.* 147), they are *hypo-*



Fig. 147.

*gynous* (*upo*, Gr. under ; *gunè*, female) *Ex.* Buttercup.



Fig. 148.

When the stamens are inserted upon the calyx, and thus stand around the pistil, they are said to be *perigynous* (*peri*, Gr. around) (*Fig.* 148). *Ex.* Peach.

When the filaments are united to the petals, so as apparently to spring from them, they are de-



Fig. 149

scribed as *epipetalous* (upon the petals) (*Fig.* 149). *Ex.* Honeysuckle.

And when the stamens are inserted upon the ovary, they are *epigynous* (*epi*, Gr. upon) (*Fig.* 150). *Ex.* Umbellifers.



Fig. 149

In certain instances the filaments are closely united with the pistil into one column, and are *gynandrous* (*gunè*, Gr. female ; *aner*, *gen.* *andros*, a male). *Ex.* Orchis.

When the number of stamens is less than twenty, they are said to be *definite* ; when more than twenty, *indefinite* ( $\infty$ ).

STAMENS consist of a stalk or support called the *filament* (*filum*, Lat. a thread), a head, or *anther* (*antheros*, Gr. belonging to a flower), and a powdery mass which the anthers contain, called *pollen* (fine flour) (*Fig.* 151).

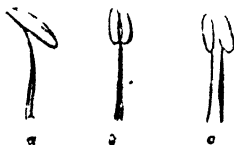


Fig. 151.

When the anther is absent, the stamen is *abortive*.

The *filament* is usually thread-like, but sometimes

becomes *petaloid* (petal-like). In the common water-lily, all stages of transition, from the simple filament to the fully-developed petal, may be traced. In the Fuchsia, Tulip, and other cultivated plants, the same transition may be often observed.

The filaments, petals, and sepals, are regarded as metamorphosed leaves, and are sometimes characterized as *staminate*, *corolline*, and *calycine* leaves.

The length of the filament varies in different plants, its function being to support the anther in such position that its contents may be shed upon the stigma.

When, of four stamens, two have the filaments long and two short, they are said to be *didynamous* (*dis*, Gr. twice; *dunamis*, superiority.)

When, of six stamens, two are longer than the four others, *tetradynamous* (*tetra*, Gr. four).

Filaments are sometimes bearded, or *stupose* (*stupa*, Lat. tow), with delicate hairs. *Ex.* Mullein.

When all the filaments are united, so as to form a tube inclosing the pistil, they are *monadelphous* (*monos*, Gr. one; *adelphos*, brother). *Ex.* Mallow.

When united in *two* bundles, whether of equal or unequal number, they are *diadelphous* (*dis*, Gr. twice). *Ex.* Pea.

When the filaments are united into *three* or more bundles, *polyadelphous* (*polus*, Gr. many). *Ex.* St. John's wort.

The **ANTHER** generally consists of two lobes united by a *connective*.

When the anthers appear to be united through their whole length to the filament on either side of it, so that the filament appears to pass between them, they are *adnate* (*Fig.* 151, *c*).

When the filament terminates at the base of the anthers, they are *innate* (*Fig.* 151, *b*).

When the filament is attached in the middle of the anthers, so that they are movable, as in many grasses, it is *versatile* (*verto*, Lat. I turn) (*Fig. 151, a*).

Anthems are commonly oval in shape; but are sometimes spherical, linear, curved, or flexuose.

The pollen is shed either by means of valves or pores. *Ex.* Lily and Heath.

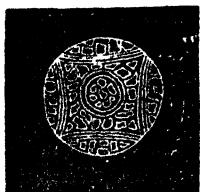
The anthers are called *introrse* (*introrsum*, Lat. inwardly), when they open on the surface turned towards the centre; *extrorse* (outwardly), when they open on the outer surface.

The anther-lobe is *unilocular* or *bilocular*, as it contains one or two cells.

Even when the filaments are united, the anthers often remain separate and distinct; but in certain cases the anthers are themselves united together, and are then termed *syngenesious* (*syn*, Gr. together; *genesis*, origin). *Ex.* Dandelion.

POLLIN consists of a number of vesicles or cases called grains containing a peculiar semi-fluid called *forilla*.

The shape of these grains is very variable, but the spherical and polygonal are the most common forms.



*Fig. 152.*

The surface is sometimes smooth, and at others studded with points or prominences (*Figs. 152 & 153*).

Pollen grains occasionally adhere in masses, or are contained in bags.



*Fig. 153.*

Although yellow or brown is the ordinary colour of pollen grains, they are sometimes of other shades.

Their function is the impregnation of the ovules.

The number of pollen grains produced is very great. It has been said that a single plant of *Wisteria sinensis* produced 6,750,000 stamens, and these, if perfect, would have contained 27,000,000,000 pollen grains.

In some cases the stamens approach the pistil in succession, and shed the pollen upon the stigma. In other cases, when the anthers are ripe, the elastic filaments are liberated from the corolla, and spring towards the pistil with a jerk, and scatter the pollen. Bees and other insects also assist in scattering the pollen from the anthers upon the stigma.

The Rosebay willow-herb, *Epilobium angustifolium*, has a four-lobed stigma, supported on a style rather longer than the filaments of the stamens. When the flower first opens, the lobes are closely applied together by their faces, and both style and stamens are pendulous (Fig. 154).

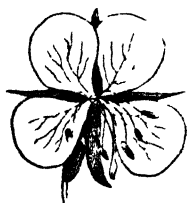


Fig. 154

As the anthers approach maturity, the style becomes erect, and the stamens commence elevating themselves (Fig. 155)

As the anthers approach maturity, the

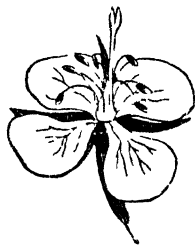


Fig. 155

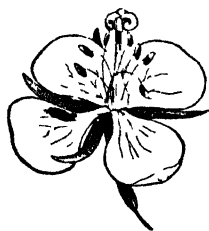


Fig. 156.

By the time that the anthers are fully matured, the lobes of the stigma have divided and curled outwards and downwards in a circinate manner, so that they may be reached by the anthers. the filaments then becoming

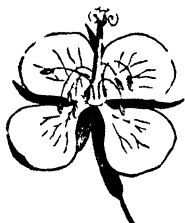


Fig 157

erect, and the pollen is discharged upon the lobes of the stigma (*Fig. 156*).

After discharging the contents of their anthers, the stamens droop and become pendulous again, whilst the style remains erect (*Fig 157*).

## SECTION XXIV.

### THE PISTIL.

The centre of a complete flower is occupied by the *pistil* (*pistillum*, Lat. a pestle). It constitutes the inner whorl and is the female organ of the plant. When mature it is converted into fruit, and contains the seeds.

It is composed of modified leaves called *carpels* (*karpōs*, Gr. fruit), or *carpellary leaves*. When it consists of but one carpel, it is *simple*, and when of more than one united, it is *compound* (*Fig 158*).



Fig 158

The *pistil* includes the *ovary*, *style*, and *stigma*. The *style* is nonessential, and is sometimes absent).



Fig 159

When the carpels of a pistil remain distinct, the term *apocarpous* (*apo* Gr. separate, *karpōs*, fruit) is applied (*Fig 159*). *Ex. Ranunculus*.

When the carpels are united a *syncarpous* (*syn*,

Gr. together) ovary is formed (*Fig. 160*).  
*Ex. Pear.*

Sometimes the ovary is *pedicellate*, or borne on a stalk or *gynophore* (*gynè*, Gr. pistil; *phoreo*, I bear). *Ex. Euphorbia.*

Sometimes the *axis* is borne beyond the ovaries to which the styles are united. This extension of the *thalamus* is called a *carpopophore*. *Ex. Geranium.*

Along the united edges of the carpels, a thickening takes place, and a projection or process, called a *placenta*, is formed, to which the ovules are attached.

When the carpels fold inwards, so that the placenta proceed to the centre and unite, they form a *central* or *axile* placenta bearing the ovules, which are then turned outwards (*Fig. 161*). *Ex. Iris.*

When the carpels are folded inwards, so that the placenta are only projections from the walls of the ovary, these are called *parietal* (*paries*, Lat. a wall) placenta (*Fig. 162*). *Ex. Poppy.*

The united edges of the carpels, when they proceed to the centre, divide the ovary into cells, and each division is then called a *septum* (fence or inclosure), or a *dissepiment* (*dissepio*, Lat. I separate).

When the dissepiments formed by the inwardly-folded carpels are obliterated, the ovules are borne on a column standing free in the centre of the ovary, and called a free central placenta, as in Pink and Primrose.

When the ovary is divided into cells by means of the *dissepiments*, it is described as *bilocular*, *trilocular*, or *multilocular*, according to the number of its cells.



*Fig. 160.*



*Fig. 161.*



*Fig. 162.*



If undivided, and consequently but one-celled, it is said to be *unilocular*.

A cell or an ovary may contain one or more ovules. If the ovary contains but one ovule, it is *monospermous*; if it contains many ovules, it is *polyspermous*.

In the fruit of cruciferous plants, the *placentæ* prolong and form a partition, called a *replum* (Lat. leaf of a door), through the entire length of the fruit.

The ovary may be *free*, or unattached to the calyx, or any other portion of the flower, when it becomes *superior*. *Ex.* Lily.

When the calyx is united to the ovary, the calyx becomes superior and the ovary *inferior*. *Ex.* Gooseberry.



Fig. 163

The **STYLE** (*stylus*, Lat. a pillar) is a prolongation of the carpels upwards, and is the support of the *stigma* (Fig. 163). Sometimes the stigma is sessile upon the ovary, and the style is absent.

When the style proceeds from the summit of the ovary, it is *apical* (*apex*, Lat. top); when from the side, it is *lateral*; and when from the base, it is *basilar*.

The style is commonly *cylindrical* and simple. It is sometimes *angular* or *petaloid*. It may be cleft or *bifurcate*.

After fertilization, if the style falls away, it is *deciduous*; but if it remains, it is *persistent*.

The **STIGMA** (Lat. a mark) consists of loose cellular tissue, and secretes a viscid substance upon its surface which causes the pollen grains to adhere when shed upon it from the anthers.

The stigma is sometimes borne upon the summit of the style, sometimes laterally, and sometimes is sessile upon the ovary.

The divisions of the stigma generally correspond to

the number of carpels in the ovary. When these divisions are large, they are termed *lobes*. Hence we may have a *bilobate* or *trilobate* stigma.

Occasionally stigmas assume very extraordinary and peculiar forms. In *Sarracenia* they are surmounted by an umbrella-shaped appendage; in the poppy they are rags diverging upon a flat sessile shield. In some instances they are globular, in others hemispherical, or ovoid. They may be naked and smooth, or feathery.

The proper limitation of stigma should be to that portion of the pistil which receives the pollen grains. In *Iris* this is a cleft at the back of the style; in *Sarracenia* it is placed beneath the umbrella-like covering; and in many orchids it is of a hollow cup-like form.

The axis, or growing-point, sometimes extends between and even beyond the carpels, in the form of a beak, as in geraniums; or it becomes enlarged and fleshy, as in the strawberry; or conical, as in the raspberry. Whichever form it assumes, or if reduced to a mere thread, it still constitutes what is termed the *torus* (Lat. a couch), *thalamus* (Lat. a bed), or *receptacle* (*recipio*, Lat. I receive).

Instances occasionally occur in which the *thalamus* grows beyond the flower and produces leaves. *Ex.* Rose.

## SECTION XXV.

### THE OVULE, OR SEED-BUD.

The small bodies attached to the *placentæ* in the ovary are the *ovules*, destined, after fertilization, to become the seeds.

Certain leaves, under favourable circumstances, de-

velop buds from their margins. The carpellary leaves bearing the ovules on their margins are of the same character, ovules being the buds produced by carpellary leaves.

Dr. Lindley has seen the ovules of the Columbine, and Professor Henslow the ovules of *Mignonette*, converted into true leaves.

Usually the ovules are contained in an ovary ; but in coniferous and cycadaceous plants the ovules are naked in the axils, or on the margins of metamorphosed leaves.

When attached immediately to the placenta, the ovules are *sessile* ; but when stalked, the prolongation by which they are attached is called a *funiculus* (a cord), or *podosperm* (seed-foot) : the point of union of the *funiculus* with the ovule is termed the *hilum* (Lat. scar of a bean), or *base*.

The ovule consists of a *nucleus* and its coverings.

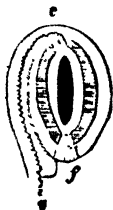


Fig. 164.

The integuments, or coverings of the nucleus, have a small aperture, which is termed the *foramen* (Fig. 164, *f*), or *micro-pyle* (*micros*, Gr. little ; *pylon*, gate).

The point of union between the base of the nucleus and the integuments is the *chalaza*.

The apex of the nucleus is turned towards this opening.

When the *foramen* is near the base of the ovule, the nucleus is inverted ; but a connection is kept up between the base of the nucleus and the base of the ovule by a process termed a *raphe* (Fig. 164, *r*).

There is a swelling at the base of the nucleus where the *raphe* is attached, which is the *chalaza* (Fig. 164, *c*), still at the base of the *nucleus*, but by inversion carried to the apex of the ovule.

In the matured ovule, or seed, the radicle is next the *foramen*.



Fig. 165.

The positions of the ovule in the ovary give rise to various terms.

When attached at the base of the ovary, it is *erect* (Fig. 165); if attached to the side, a little above the base, and with the ovule pointing upwards, it is *ascending* (Fig. 166).



Fig. 166.

If it is suspended from the top of the ovary, it is *inverted*, or pendulous (Fig. 167).



Fig. 167.

And if from the wall near the summit, it is, in that case, *suspended* (Fig. 168).

The curvatures of the ovule are also of importance.



Fig. 168.

It is *orthotropal* (*orthos*, Gr. straight; *tropos*, mode) when erect (Fig. 169).



Fig. 170.

*Camptotropal* (*kamptos*, Gr. curved), when curved downwards towards the placenta (Fig. 170)



Fig. 169

*Anatropal* (*anatrepo*, Gr. I subvert), when not only curved downwards but also grown to the lower half (Fig. 171).



Fig. 172.

*Campylotropal* (*kampulos*, Gr. curved), when attached at the middle (Fig. 172).



Fig. 171.



Fig. 174.

*Lycotropal* (*lucos*, Gr. a hollow disk), when horseshoe-shaped (Fig. 173).



Fig. 173.

*Semianatropal* (*semi*, Lat. half), when half free (Fig. 174).

In Cryptogamic plants, there being no ovules, the

functions of these bodies are performed by other minute analogues, called *spores*.

When the process of fertilization takes place, the mature pollen is discharged from the anthers upon the stigma, to which it is attached by means of the viscid secretion already alluded to. Whilst in this position, the pollen grains develop small tubular processes, which pass through the loose cellular structure of the stigma, down the style to the ovary. These tubes then penetrate the ovules, and discharge into them the contents of the pollen grains, and thus a union is effected between the fovilla, or fertilizing principle of the pollen, and the semi-fluid contents of the ovule. After this process, the style commonly falls away, and the ovary ripens into fruit, inclosing fertile seeds.

## SECTION XXVI.

### THE FRUIT.

The mature ovary constitutes the *fruit*, and the matured ovules the *seeds* of plants.

In the popular acceptation of the term *fruit*, other parts of the flower are also sometimes included; as the pulpy disk, or receptacle, in the strawberry, the united calyx and ovary in the apple and gooseberry, and the bracts and calyx united into a cupula, or cup containing the acorn.

Important changes sometimes occur in the process of transformation of ovary into fruit. The ovary may be *unilocular*, and afterwards develop into a *multilocular* fruit, or the ovary may be *multilocular* and the fruit *unilocular*. In the ash, a two-celled ovary is re-

placed by a one-celled fruit. In *Cassia fistula*, a one-celled ovary becomes a multilocular fruit.

The placentæ may also undergo a pulpy development, inclosing the seeds, as in the grape.

The envelope of the seeds is called the *pericarp* (*peri*, Gr. around; *karpos*, fruit), and ordinarily consists of three layers

The *epicarp* (*epi*, Gr. outside) is the external layer.

The *mesocarp* (*mesos*, Gr. middle), the intermediate, and—

The *endocarp* (*endon*, Gr. within), the internal layer.

Sometimes the three are blended, as in the nut; at others separable, as in the peach. In the latter instance the skin is the *epicarp*, the pulp the *mesocarp*, and the hard shelly covering of the seed, or kernel, the *endocarp*.

The inner union of the carpellary leaves is called the *ventral* (*venter*, Lat. the belly) *suture* (*sutura*, Lat. a seam); the outer, corresponding to the rib of the leaf, the *dorsal* (*dorsum*, Lat. the back) *suture*.

The sutures may be so firmly united as not to give way on the ripening of the fruit: it is then said to be *indehiscent*: when the sutures open to allow the seeds to escape, the fruit is termed *dehiscent* (*dehisco*, Lat. I open). By dehiscence the pericarp becomes divided into parts called *valves*.

Indehiscent fruits may be *dry*, as in the filbert, or *fleshy*, as the apple.

Dehiscent fruits may separate by one suture or both, and they may carry the placenta with them, or leave it standing in the centre. In the latter case it is called a *columella*.

The separation may proceed from the base to the apex, or from the apex to the base. Transverse, or operculate divisions, sometimes occur.

Dehiscence may also take place by means of orifices or *pores*, as in the poppy.

Fruits composed of a single carpel may dehisce by one suture only, or by both together; this kind of dehiscence is called *sutural*. *Ex.* Pea.



Fig. 175.

Fruit composed of several united carpels may dehisce through the dissepiments, so that it is again resolved into its original carpels. This mode of dehiscence is *septicidal* (*septum*, Lat. inclosure; *cædo*, I cut) (Fig. 175). *Ex.* Foxglove.



Fig. 176.

If the carpels remain united at their edges and dehisce through the back of the locuments, each valve being formed by the halves of contiguous cells, it is *loculicidal* (*loculus*, Lat. cell) (Fig. 176). *Ex.* Yellow lily.



Fig. 177.

If the fruit opens by the dorsal suture and the septa remain attached to the centre, it is called *septifragal* dehiscence (*septum* and *frango*, Lat. I break) (Fig. 177).

Fruits may also be the result of one flower, as in ordinary instances; or of several united, as in the Pine-apple.

When the bracts and floral envelopes are united in the fruit, it is termed *anthocarpous* (*anthos*, Gr. flower; *karpós*, fruit).

Fruits formed out of one or more free carpels are said to be *apocarpous* (*apo*, Gr. separate). *Ex.* Bean.

When several carpels are united, they constitute a *syncarpous* (*syn*, Gr. together) fruit. *Ex.* Orange.

Indehiscent fruits may be classed in two divisions, containing *one* or *more* seeds respectively.

Indehiscent fruits containing *one seed* may be again subdivided into *dry* and *fleshy*.

Dry indehiscent fruits with one seed are :—

**ACHENIUM** (*a-chaino*, Gr. I open not).

With a pericarp separable from the seed (*Fig. 178*). *Ex.* Sunflower.



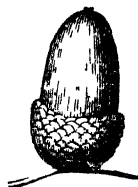
*Fig 178*

**CARYOPSIS** (*karua*, Gr. a nut; *opsis*, appearance). With a pericarp inseparable from the seed. *Ex.* Wheat.

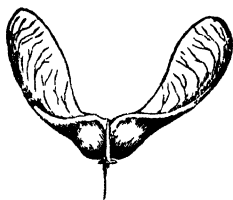
**UTRICLE** (*uter*, Lat. a bladder) With an inflated pericarp. *Ex.* Chenopodium.

**GLANS** (Lat. an acorn). With a hardened pericarp, accompanied

by bracts at the base, or inclosed in an involucre (*Fig 179*) *Exam* Acorn, Chestnut.



*Fig 179*



*Fig 180*

*Samara* (Lat.

seed of an elm). With a winged pericarp (*Fig 180*).

*Ex* Sycamore, sometimes included under *Glans*

Pulpy indehiscent fruits with one seed :—

**DRUPE** (*drupæ*, Lat. un-ripe olives) With a succulent, or fibrous mesocarp, and hard endocarp (*Fig. 181*).



*Ex.* Cherry.



*Fig 181*

*Euterio* (*elai-*

*ros*, Gr. a companion). Several small drupes aggregated together (*Fig 182*)

*Ex.* Raspberry.



Pulpy indehiscent fruits with more than one seed are :—

**BERRY** (*bacca*). A succulent fruit, in





Fig. 183.

which the seeds are immersed in a pulpy mass (Figs. 183, 184). *Ex* Gooseberry.

*Pepo* (*pepon*, Gr. a pumpkin). With three or more parietal placentæ bearing seeds, often with a central cavity. *Ex*. Melon.



Fig. 184.

*Hesperidium* (golden fruit of Hesperides) is a name given to the fruit of the orange tribe, in which the epicarp and mesocarp form a separable rind.

N.B.—The *Pepo* and *Hesperidium* are modifications of the *B* riy.

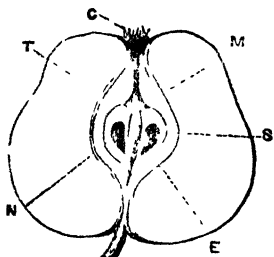


Fig. 185.

*POME* (*pomum*, Lat. an apple). The calyx, with the epicarp and mesocarp, form a fleshy mass, and the endocarp is scaly or horny, forming separate cells inclosing the seeds (Fig. 185). *Ex*. Apple.

In the annexed engraving, *c* represents the remains of the stamens, and free limbs of the calyx; *T*, the calyx tube, become succulent and adherent to *E*, the epicarp; *M* indicates the mesocarp; *N* the endocarp, and *s* the seeds.

Dehiscent fruits are all dry.

Those which are apocarpous are :—

**FOLLICLE** (*folliculus*, Lat. a little bag). A carpel having no dorsal suture, and dehiscing by the ventral suture (Fig. 186).



**LEGUME** (*legumen*, Lat. pulse). A carpel having dorsal and ventral sutures, and dehisc-

Fig. 186.

ing by both or either (*Fig* 187).

Those which are syncarpous are.—



*Fig* 187.

### CAPSULE

(*capsula*, Lat. a little chest) A dry fruit opening by valves or pores.

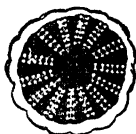
Valvular capsule *Ex* Foxglove

Porous capsule (*Figs*. 188, 189) *Ex*. Poppy.

Sometimes the capsule dehisces by a lid, in

which case it is called

a *Pyridium* (a little box) (*Fig* 190). *Ex* Henbane.



*Fig* 189.

*Fig*. 188

*Silique* (*silique*, Lat. a husk or pod). A variety of capsule

opening by two valves, detached from below upwards, leaving the seeds attached to both sides of a *replum* (*Fig*. 191). *Ex*. Wallflower.



*Fig* 190

*Silicle* (*silicula*, dimin. of *silique*), a pouch or short pod. *Ex*. Candy-tuft.

Anthocarpous fruits:—

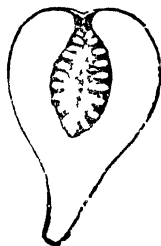
SOROSIS (*soros*, Gr. a cluster).

A succulent anthocarpous fruit. *Ex*. Pine-apple.

SYCONUS (*sucon*, Gr. a fig).

A pulpy hollowed axis, inclosing the achenia of numerous flowers (*Fig*. 192). *Ex*. Fig.

STROBILUS (*strobilus*, Gr. a spike)



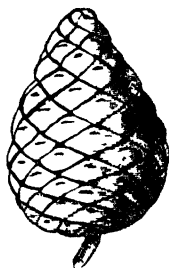


Fig. 193.

covered with scales or bracts, with seeds at their base (Fig. 193). *Es.* Fir cone. Hop.

## SECTION XXVII.

## SEED.

The *seed* is the matured ovule.

When the seeds are inclosed in a seed-vessel, as in most flowering plants, such plants are termed *angiospermous* (*aggeion*, Gr. a vessel ; *sperma*, a seed).

In conifers the seeds are naked, or not provided with a seed-vessel ; hence such plants are termed *gymnospermous* (*gymnos*, Gr. naked).

In mignonette the seed-vessels open very early and expose the seeds.

The seed has also its own coverings, independent of the pericarp.

The general covering of the seed is called the *spermoderm* (*derma*, Gr. covering). It consists of an external membrane, the *testa* (shell) or *episperm*, and an internal lining or *tejmen*, the *endopleura* (*endon*, Gr. within ; *pleura*, side).

The *episperm* or *testa* is cellular, and is often coloured. In the Circassian bean and crab's-eye bean they are of a bright red, and in cotton they are covered with hairs.

The *endopleura* is cellular also. It is generally thin and transparent, and is often closely applied to the embryo.

An additional covering to the seed is present in a few instances, which is derived from an expansion of the *placenta*, after the fertilization of the ovule. This

constitutes the *mace* of the nutmeg, and is termed the *arillus*.

The attachment of the seeds, as of the ovule, is called a *funiculus* (Lat. a little cord). Occasionally it is of such length that the seeds are pendent from the n as from a cord. *Ex.* Magnolia.

The scar left upon seeds after detaching them from the funiculus is the *hilum* (Lat. the scar of a beard).

The seeds sometimes contain, interposed between the embryo and the seed-coat, a substance called *albumen* (Lat. white of an egg), which consists of starch, oil, and nitrogenous compounds.

Seeds in which the albumen is present are called *albuminous*, and those from which it is absent, *ex-albuminous*.

The albumen forms the great bulk of the cocoa-nut; and the hard substance of the vegetable-ivory nut, and the horny substance of the coffee berry are alike albumen.

The EMBRYO (*embryon*, Gr. a fœtus), or young plant, consists of *radicle* (*radix*, root), or end of axis (*r*), *plumule* (*plumula*, feather), or young stem (*q*), and *cotyledons* (*c*), or seed-leaves (*Fig.* 194).

Sometimes the embryo occupies the entire seed, and at others only a portion. The seeds of some plants contain more than one embryo.

The plumule may generally be seen lying between the cotyledons.

The class of plants now associated under the name of *Endogens* correspond to another division formerly adopted, called *monocotyledons* (*monos*, Gr. one), from the fact of their having but one cotyledon.

Plants having two cotyledons, and which correspond to *Exogens*, were called *dicotyledons*.



*Fig.* 194

Embryos containing more than two cotyledons are said to be *polycotyledonous*.

Embryos deficient in cotyledons, as in *Cuscuta*, which has no leaves, are *acotyledonous*.

Cotyledons are generally entire, but sometimes lobed; they are either flat or folded in various ways.

The cotyledons may be *conduplicate* (Lat. folded together) or folded laterally (Fig. 195).

Fig. 195. Or *reclinate* (Lat. bent downwards), folded from apex to base (Fig. 196).

Or *convolute* (Lat. rolled over), rolled up laterally (Fig. 197).

Or *circinate* (*kirkos*, Gr. a circle), rolled up like the young fronds of ferns (Fig. 198).

Or *contortuplicate* (Lat. twisted into plaits), crumpled (Fig. 199).

When the cotyledons have their faces applied to each other, and the radicle is folded on their edges, so as to be *lateral*, the cotyledons are said to be *accumbent* (*accumbo* I lie at the side) (Fig. 200).

When the cotyledons are applied in the same manner, and the radicle is folded on their back so as to be dorsal, the cotyledons are *incumbent* (*incumbo*, I lie on the back) (Fig. 201).

The two latter forms and terms are applicable to the seeds of cruciferous plants, in which the distinction becomes one of importance.

The seed contains the germ of a new plant. Its function is the reproduction of its species. When matured, the seeds are detached from the parent plant and dispersed in various ways. Some are expelled to



Fig. 195.



Fig. 196.



Fig. 197.



Fig. 198.



Fig. 199.



Fig. 200.



Fig. 201.

a considerable distance by the elastic bursting of the seed-vessel ; others are supplied with appendages, by means of which they are readily wafted through the air ; and others fall to the ground and germinate in the immediate neighbourhood of their parent.

Seeds are sometimes produced in immense numbers. One capsule of the poppy has been found to contain 40,000 seeds.

## SECTION XXVIII

### GERMINATION.

The period during which seeds retain their vitality is very variable. Melon-seeds have been known to vegetate after forty years. Seeds capable of germinating have been stated to have been found in a Roman tomb fifteen or sixteen centuries old. Seeds have also germinated which were found in a sand-pit twenty-five feet deep, where they were supposed to have been deposited at least 2,000 years ago. Other seeds require planting soon after ripening to insure germination.

Certain conditions are essential to germination.

*Moisture* is of great importance. Dry seeds will not vegetate. Dampness is necessary to enable the young plant to burst its hard covering.

*Temperature* should be such as is suited to the character of the plant to be reared.

*Air* is also essential. Seeds buried deep in the soil do not germinate in that condition.

*Darkness* is also favourable. Seeds germinate best when excluded from the light.

Important internal changes take place in seeds during germination. Starch is converted into dextrine, or sugar, by oxidation, and diastase is developed

During these changes considerable heat is evolved; substances which were before insoluble become soluble. The seed is swollen, the embryo enlarges and ruptures the integument, protrudes, and the growth of a new plant commences. During its early stages the young plant is nourished by the cotyledons until the primary leaves are formed; the radicle invariably proceeding downwards, and the plumule upwards from the *collum* or neck, which lies intermediate between the two.

The germination is *exorhizal* (*exo*, Gr. outwards; *rhiza*, root) when the radicle is directly prolonged into the root. *Ex.* Maple.

It is *endorhizal* (*endon*, Gr. within) when the roots pierce through the integument at the extremity of the radicle. *Ex.* Wheat.

The ruptured integument surrounding the base of the young root as with a sheath, is termed the *coleorhiza*.

In acotyledons, there being no distinct embryo in the spore, it germinates from any part of its surface, and is termed *heterorhizal* (*eteros*, Gr. diverse).

Some seeds will germinate within twenty-four hours of planting. *Ex.* Cress.

Seeds with a stony pericarp will sometimes lie dormant in the soil for upwards of a year.

Some seeds will germinate while still attached to the plant, and young ferns commence their existence attached to the fronds of their parents.

The leaves of *Bryophyllum calycinum*, when placed upon damp soil, will produce buds, which develop into young plants, upon their edges.

In other plants buds are developed in the axils of the leaves, which are capable of germination under favourable circumstances.

## SECTION XXIX.

## REPRODUCTION OF ALGÆ.

Seaweeds are furnished with a double system of fructification. The majority of the red series have this double fructification, the *capsular* on one plant, and the *granular* on another. A great modification of shape exists, but there is a unity of principle, so that they are at once alike and unlike.

Dr. Lindley says, "I am very much inclined to adopt the opinion that the two sorts of fructification observable in algæ are the first attempts at the agency which, in higher plants, performs the office of sexes, without, however, having their qualities established, and each capable of producing a new plant without the aid of the other."

In the *capsular* fruit, we meet with capsules of different forms, according to species, containing tufts or bundles of spores. The capsules vary in size and form; one kind is termed a *ceramidium* (*keramos*, Gr. a little measure), another is called a *coccidium* (*kokkos*, Gr. a berry; *oidos*, resemblance), and others are termed *favellæ*.

In Fig. 202 (1) is represented a magnified portion of a frond of *Polydora* bearing a ceramidium, and Fig. 202 (2), the ceramidium only, still more magnified.

The *granular* fruit consists of *tetraspores* (*tetra*, Gr. four), or granules, which, on being examined by the microscope, are found to be composed of four spores or seeds, united together. These granules are imbedded in the terminal por-

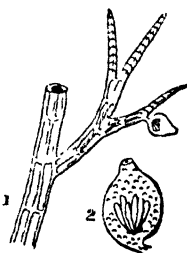


Fig. 202.



tion of the frond or its branchlets, or occasionally

supported on short pedicels, collected in *conceptacles* or *stichidia* (*stichos*, Gr. a row).

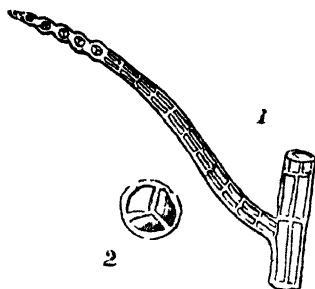


Fig. 203.

In Fig. 203 (1) is shown a portion of a frond of *Polysiphonia*, bearing tetraspores, and Fig. 203 (2), a tetraspore removed and more highly magnified.

*Nemathecia* (*nema*, Gr. a thread) are warts, concealed under leafy processes, and composed of thin moniliform filaments. This is a kind of fructification concerning which but little is known.

*Antheridia* (*anthos*, Gr. a flower) are not uncommon. They are little cells, in each of which is contained one or more *spermatozoids* (*sperma*, Gr. seed; *zoon*, life).

**SPERMATIZOIDS** are thread-like bodies, varied in form, but generally spiral, and furnished with movable silia. They are very small, and, after escaping from their parent cells, continue to move about for some time, until they have sought out and fecundated the spores.

The seed consists of a cell filled with a dark-coloured semi-fluid mass, which is called the *endochrome* (*endon*, Gr. within; *chroma*, colour). This seed produces a perfect plant like its parent; but the process of fecundation is still involved in mystery.

## SECTION XXX

## REPRODUCTION OF LICHENS.

In Lichens (*lichenos*, Gr. a tetter or wart) we have a double reproductive system.

The *primary* consists of organs called, respectively, *apothecia*, *spermatogones*, and *pycnides*.

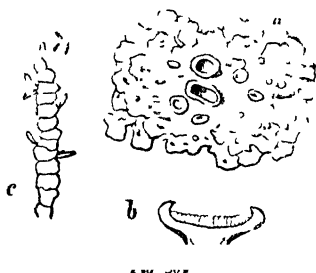
*Apothecia* (*apothékè*, Gr. a repository) generate and protect the *spores* from which new plants are developed.

*Spermatogones* (*sperma*, Gr. seed; *gonè*, generation) produce and discharge bodies called *spermatia*, whose function appears to be the fertilization of the spores.

*Pycnides* (*pyknitès*, Gr. denseness), which give rise to spore like bodies called *stylospores*, whose function is undetermined.

**APOTHECIA** appear like peltate disks on the surface of lichens (*Fig. 201, a*).

They are sometimes *open* (*Fig. 204, b*), as in a section of the lichen family, called *gymnocarpous* (*gymnos*, Gr. naked; *karpous*, fruit), and sometimes *closed*, as in the *angiocarpous* section (*aggos*, Gr. a vessel).



In *gymnocarpous* lichens, the *apothecium* consists of a more or less flattened disk called a *thalamium* (*thalamos*, Gr. a receptacle), which contains the spores, and an *exciple* (*excipio*, Lat. to receive), or envelope, which

surrounds and protects it. In this case the upper surface of the *thalamium* is exposed (*Fig. 204, b*).

In *angiocarpous* lichens, the *exciple* incloses the *thalamium* in a globular envelope, from which the spores issue, when ripe, by means of a pore or fissure. In these instances the organ is termed a *perithecium* (*peri*, Gr. around).

The *thalamium* consists of a series of elongated cells, placed on end, closely packed together and united by means of a tenacious mucus. These cells arise from the smaller, somewhat irregular cells, which constitute the base of the *thalamium*, and called the *hypothecium* (*upo*, Gr. under).

The elongated cells thus packed together upon the hypothecium, are of two kinds; *thecæ* (*thèkè*, Gr. a sac), and *paraphyses* (*p. raphusis*, Gr. an offset).

*Thecæ* are the parent cells of the spores. They are elongated cells, containing, at first, a mucous matter which becomes granular, and ultimately consolidates into eight, four, or two spores. When the spores are mature, the *theca* ruptures, and the spores escape.

*Paraphyses* are elongated, club-shaped bodies, thinner and longer than *thecæ*. They consist of a series of six or eight cells, attached end to end, like a string of beads, and contain mucus; the terminal cell being larger, and, with its contents, coloured. They precede the *thecæ* in order of development, have a distinct structure, and, apparently, a distinct function not yet clearly defined.

The *spores* (*spora*, Gr. a seed) are generally ovoid in form, and consist of one or more cells. In their early stage they are generally colourless, acquiring a yellow tint as they ripen. The young spore contains mucus and granular matter, sometimes mixed with globules of oil. At maturity these become fused into a mass, partaking frequently of an oily nature.

*Spermagones* are usually minute capsules, imbedded in the *thallus*, and opening on its surface by pores. From the inner wall a number of delicate filaments project, called *sterigmata* (*sterigma*, Gr. a support); from their ends or sides the *spermatia* are developed. These escape from the *spermagone*, when mature, which takes place long before the maturity of the *spores* (*Fig. 204, c*).

These *spermatia* are minute linear bodies, colourless and transparent; not possessed of cilia or other appendages, but often exhibiting molecular motion.

The *spermagones* only appear as black point-like bodies, scattered or clustered on the surface of lichens. No proof has yet been obtained of the fecundating influence of *spermatia*; it is only still matter of probability.

*Pygidies* are rare bodies, differing from *spermagones* in being larger, and supporting, upon pedicels, bodies resembling spores, and called *stylospores* (*stulos*, Gr. a pillar). These are oblong and colourless, and contain granular matter.

The *secondary* system consists of *gonidia*.

Beneath the upper or cortical layer of the *thallus* of lichens, is a thin bright-green layer of globular cells, loosely aggregated, called the *gonidic* layer. These isolated cells are the *gonidia*. They assume the offices, and partake of the character, of both vegetative and reproductive cells, and are peculiar to the *thallus* of lichens. They frequently burst through the outer layer of the lichen and appear as a powdery mass on the surface, termed *soredia*, giving it a powdery or frosted appearance. They appear to be cellular buds or reproductive cells, destined, without preparatory fertilization, to multiply the individual.

## SECTION XXXI.

## REPRODUCTION OF FUNGI.

The common mushroom is a well-known example of the group of cryptogamic plants included under the general name of Fungi. Let us employ this plant to illustrate our descriptions.

In this instance we have a number of individual plants, composed of thread-like filaments, which constitute what is called the *mycelium* (*mykēs*, Gr. fungus), or *spawn*. This is either concealed beneath, or appears on the surface of the matrix, upon which the fungus vegetates.



Fig. 205.

From a community of the individual plants which constitute the *mycelium* (Fig. 205, *m*), a common pedicel, or *stipe* (Lat. a trunk), proceeds (Fig. 205, *s*), surmounted by a round knob or protuberance, which enlarges and assumes the form of a cap (Fig. 205, *p*), and is called the *pileus* (Lat. a cap). In the process of growth, whereby the

rounded summit of the stipe is converted into the cap-like form, the wrapper which envelops it ruptures, or breaks away from the stipe, leaving a ring, or *annulus* (Lat. a ring), showing the point of attachment, around the stipe.

The under portion of the *pileus*, in agarics, consists of a number of plates or *gills* radiating from the stipe. These are covered with a membrane called the *hymenium* (*umèn*, Gr. a membrane), which bears the spores, or reproductive organs.

The spores are borne on simple or branched processes, called *sporophores* (*spora*, Gr. a spore; *phorio*, I bear), or *basidia* (*basis*, Gr. a base), or are contained in *thecae* (*theca*, Gr. a sac), *cystidia* (*kustis*, Gr. a bladder), or *asci* (*askos*, Gr. a bag), accompanied by other bodies called *antheridia*, or *paraphyses* (Gr. an offset).

The true fruit is formed on two plans. In one, the tips of certain threads swell into bodies surmounted by little *spicules* (Lat. arrow-head), which each give rise to a single cell. This mode is called *acrosporous* (*akros*, Gr. summit); in such cases the spore ultimately falls off.

In the other method certain threads swell out and form bags or tubes containing eight spores, or a multiple of that number. This mode is called *ascigerous* (*askos*, Gr. a bag or bottle).

There is also another medium of propagation, by means of cells or buds, which fall from the ends of filaments, and to which the name of *conidia* has been given.

*Spermatia* have also been discovered; but little is known of them except that they appear to be analogous to the *spermatozooids* of sea-weeds.

Fungi are made up of a number of cells similar to those represented in *Fig. 206*, obtained from a common *Boletus* magnified about 180 diameters.



*Fig. 206.* of which the yeast-plant

may be taken as an example (*Fig. 207*), are single and simple cells. Their method of increase has already been described.

*Zoospores* have also been found in some of the microscopic species.

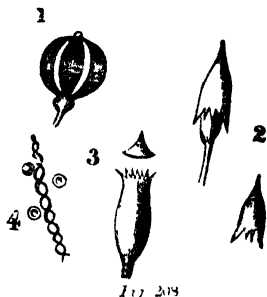


*Fig. 207.*

## SECTION XXXII.

## REPRODUCTION OF MOSSES.

The spores of mosses are borne in spore-cases, or *thecae*, which dehisce in the split-mosses by valves (*Fig. 208, 1*). In urn-mosses the dehiscence is operculate (*Fig. 208, 3*).



The organs of fructification in mosses are of two kinds. The most conspicuous consists of a *sporangium*, or spore-case, an urn-shaped capsule, supported upon a stalk or *seta*, and, at first, covered with a

*calyptra*, or hood (*Fig. 208, 2*), which is sometimes *dimidiate*, or split on one side; at others *mitriform*, or cleft at the base. When the *calyptra* is removed, the *sporangium* is found to possess a lid, or *operculum* (Lat. a cover), which, when it falls off, shows the mouth of the urn, or *sporangium*, to be sometimes crowned with a *peristome* (*peri*, Gr. around; *stoma*, mouth), or fringe, beneath which is an elastic *annulus*, or ring; and sometimes naked.

In the centre of the urn is a *columella*, and occasionally a transverse *septum* or *epiphragm* (*phragma*, Gr. partition) is interposed between the *operculum* and the contents of the urn. Within the urn are contained a number of spherical spores, each of which divides into four sporules. In some instances, spiral filaments (*Fig. 208, 4*), called *elaters* (Gr. impellers), are also present, *i. e.* in the moss-like plants called *Hepaticæ*.

When a fleshy protuberance occurs at the base of the theca, and on one side, it is called a *struma* (Lat. a swelling).

The urn usually grows from a fleshy tubercle called an *apophysis* (*apophysis*, Gr. excrescence).

To the other kind of organs, the name of *antheridia* or *staminidia* has been given. They are found in the axils of the leaves, and consist of membranous sacs, opening at their summit, and discharging a turbid fluid, and *phytozoæ* (*phuton*, Gr. a plant; *zoon*, an animal; the antheridia are generally in clusters mixed with *paraphyses* (Gr. an offset),

A *phytozoa* is a peculiar body, rolled up in a circular or spiral manner, which exhibits movements at a certain period of its existence, from which the name has originated (*Fig. 209, b*).

The Rev. M. J. Berkeley says: "Perennial mosses and *Hepaticæ* so far agree with phænogams, that there is a fresh crop of fruit every year; but then the result of impregnation is not a seed, but an organ, which produces the reproductive bodies or spores, much after the fashion in which pollen grains are generated. Ferns and club-mosses, though living to a hundred years, and producing a crop of spores each year, are impregnated but once, and that before the plant has assumed its true habit. The result of impregnation in these, is something more or less resembling the embryo of a phænogam, and, like that, produces, by progressive development, a perfect plant."

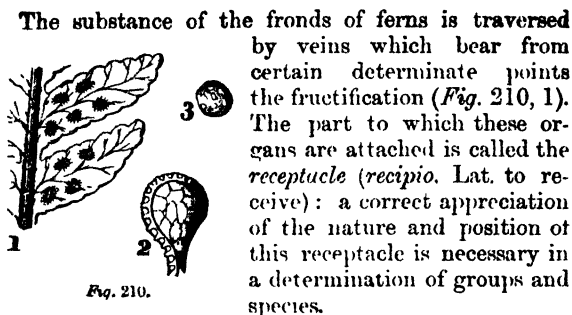


*Fig. 209.*



## SECTION XXXIII.

## REPRODUCTION OF FERNS.



The substance of the fronds of ferns is traversed by veins which bear from certain determinate points the fructification (*Fig. 210, 1*). The part to which these organs are attached is called the *receptacle* (*recipio*, Lat. to receive): a correct appreciation of the nature and position of this receptacle is necessary in a determination of groups and species.

Each mass or cluster of seed-cases is called a *sorus*. This consists of a number of *spore-cases*, *sporangia* (*spora*, Gr. a seed, *aggon*, a vessel), or *thecæ* (*theke*, Gr. a sac), minute roundish bodies, often nearly surrounded by an elastic band or *ring* (*Fig. 210, 2*), which is sometimes wanting. When mature, the ring, by its elasticity, causes the *thecæ* to burst and discharge the *spores*, as a minute, almost impalpable dust (*Fig. 210, 3, magnified*).

When the ring is present, the *sporangia* are stalked; but when absent, they are sessile.

The *thecæ* sometimes arise from the surface of the frond, while at other times they spring from below, having a cuticular covering in the form of an *indusium* (Lat. a shirt), or *involucre* (*involucrum*, Lat. a cover).

The margin of the frond may be so folded as to cover the *thecæ*, and at times the whole frond is converted into clusters of *thecæ*.

The *indusium* is commonly a membranaceous scale of the form of the *sori*, inclosing the young *thecae*; but ultimately becoming ruptured and thrust back or cast off (Fig. 211). In some species the *indusium* is cup-shaped, containing the spore-cases; but this form is rare in British ferns.

The *sori* are said to be *marginal* when they project beyond the margin of the frond, and *dorsal* when placed on some part of the under surface of the frond.

Certain cellular *papillæ* (Lat. teats) on the margin, or upper surface of the fronds, have been considered by some as antheridia, each of the cells containing a spiral fibre. But this question cannot be considered as yet settled beyond dispute. There are some who contend for a duality of organs in ferns analogous to the anthers and ovules of flowering plants, and state that among the *thecae*, filaments are found which are equivalent to stamens.

The following is the most generally accepted history of the reproductive development of ferns. The spores at first germinate by the protrusion of a tubular process, which enlarges into a small leafy plate, or *prothallus*, with filamentous rootlets. When completely formed, this *prothallus* bears on its under surface bodies of two kinds, viz., *antheridia* and *archegonia*. The *antheridia* are unicellular structures, in which a second cell is formed, the interior of which becomes divided into a number of minute *sperm-cells*. When ripe, the sperm-cells escape, each containing a *spermatozoid*. The *archegonia* are formed of four tiers

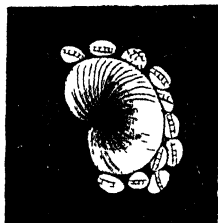


Fig 211

in which lies a germinal body, having somewhat the character of an ovule, which ultimately becomes fertilized by the entrance of the spermatozoids liberated from the antheridia. The fecundated embryo, or ovule-like body which lies in the embryo sac, then develops as a bud, and produces true leaves, which mature into a plant resembling the original parent from which the spore first sprung.

#### SECTION XXXIV.

##### VEGETATIVE PHENOMENA.

**ROTATION.**—This is a movement of fluids confined to the cells themselves, and is the result of vital action. In young cells, and in the cells of aquatic plants of all ages, this movement has been observed. It proceeds in each cell independently of its neighbour. In some the movement will be slow, in others rapid, and is generally most evident near the circumference passing up one side and down the other.

**CIRCULATION** is the general motion, in plants, of fluids absorbed by the roots upwards into the leaves and back again to the stem. This current enters by the extremities of the roots, passes up by the woody portions of the stems of exogenous plants, and the vascular bundles of endogens, into the leaves, where much of the water which the fluid, hitherto termed *ascending sap*, contained, is evaporated under the influence of light and heat, and the thickened fluid enriched by carbonic acid absorbed from air, now called the *descending sap*, returns by the liber of the bark to the stem, whence it passes horizontally by means of the medullary rays, and is diffused through the plant depositing, in its progress, the materials essential to its growth and vigour.

**ASSIMILATION.**—In the upward course of the sap, it

water and carbonic acid are partly decomposed and deposited. Upon reaching the leaves exposed to light, water is given off, carbonic acid absorbed, and chlorophyll formed by the decomposition of carbonic acid and water; oxygen is returned to the atmosphere, and carbon, nitrogen, and hydrogen assimilated for the use of the plant. *Light* is the main cause of this assimilating process, which, therefore, does not take place during the night. The parts of plants excluded from the light by artificial means are blanched, or rather prevented forming the colouring and other secretions for which light is essential. *Ex. Endive.*

The average rate of perspiration in plants has been estimated as equal to seventeen times that of a man.

During the night, plants re-absorb oxygen from the air and part with a small quantity of carbonic acid. It is a vulgar error to suppose that the latter is given off in sufficient quantity by plants growing in a room to have any appreciable or detrimental effect upon the atmosphere.

HEAT is developed by plants during growth, sometimes to a considerable extent. Tubers and bulbs have been found to possess, during winter, a temperature  $6^{\circ}$  or  $7^{\circ}$  above the external air. In germination, much heat is evolved, and again during flowering. The spathes of araceous plants, which contain many flowers, have been subjected to experiment. In some of these the thermometer has risen at sunrise to  $30^{\circ}$  above the surrounding air. The bulb of a thermometer plunged 11 inches deep in the trunk of a walnut-tree rose  $2^{\circ}$  or  $3^{\circ}$ . This, however, was due to the absorptive power of the trunk for the sun's heat. A species of *Colocasia* was found to attain a heat of  $10^{\circ}$  above the atmosphere in the middle of the day. The exciting cause of this evolution of heat may be found in the oxidation going on in plants at all times, but with greater vigour during the flowering season.

**IRRITABILITY.**—Some of the most simple forms of Algæ have an oscillatory motion, and the spores of others move about for some time, as it has been supposed, by means of vibratile ciliæ. Plants of a higher order exhibit movements incidental to peculiar states of the atmosphere. Some flowers are hygrometric, others close at stated periods. The sensitive plant (*Mimosa sensitiva*) closes up its leaves when touched. The leaves of *Desmodium gyrans* move about by rapid jerks. A species of *Dionea*, called Venus's fly-trap, folds up if an insect alights. The leaflets of the wood sorrel fall back at the approach of night. Many other plants exhibit staminal movements. In the Passion-flower the styles move towards the stamens. Thus, in some part or other, every plant exhibits irritability.

**LUMINOSITY** has been noticed chiefly in Fungi. A species of Agaric, in Western Australia, is said to afford a phosphorescent light of sufficient intensity to read by. Decaying wood, called *touchwood*, caused by the mycelium of fungi, is often phosphorescent; and in Brazil certain mushrooms give out a light like that of fire-flies. Luminosity has also been attributed to some phanerogamous plants; but the evidence of its existence is questionable.

**ODOURS** are given off from some plants only during the day, from others only at night. Certain plants, as the woodruff, are fragrant only when dried, others only whilst in the fresh state. From the investigations of certain German botanists, we learn that white flowers have the largest number of fragrant species, and that a large proportion of yellow and brown flowers possessing any odour, are disagreeable. Of 1,193 white flowers examined, 187 were odoriferous, whilst only 12 were disagreeable. Meteorological changes greatly influence the odours of plants.

## SECTION XXXV.

## EPIPHYTES AND PARASITES.

Plants which grow without attachment to the soil are called *Epiphytes* and *Parasites*.

*Epiphytes* (*epi*, Gr. upon ; *phuton*, a plant), or air-plants, are generally Orchids, or their allies. They are found in tropical climates attached to the surface of trees, and are sometimes nearly covered with a mass of showy flowers. Some of these aerial plants develop long root-like processes, clad with a green epidermis containing stomata. These serve all the purposes of leaves, and would rather deserve to be considered as such did they not often possess a layer of delicate air-cells covering the epidermis, which has caused them to be termed by some botanists *coated roots*.

*Epiphytes* derive very little of their nourishment from the matrix on which they flourish, but chiefly from the medium in which they grow.

*Parasites* (*para*, Gr. beside ; *sitos*, food) grow and prey upon other plants. They are more numerous than epiphytes, and are found in all climates. Some of these are flowering plants, and others without any such organs. Some are brownish, without true leaves, but provided with scales. Others are green, and possessed of leaves. To the former the dodder belongs, and to the latter the mistletoe.

A remarkable group of parasites are found in the Eastern Archipelago and South America, which produce immense flowers, but no leaves. These extraordinary plants are of very rapid growth. It is reported of them, that the *Rafflesia*, which, when full grown, is a yard across, and when unexpanded is

as large as a middle-sized cabbage, only takes about three months for its complete formation.

Some parasites attach themselves to the roots of plants by suckers. *Ex.* Broom-rape.

Others insinuate their extremities through the bark into the wood of trees, and flourish on their branches. *Ex.* Mistletoe.

A great many Fungi are true parasites, producing diseased states of corn, and dry-rot in wood, or are found growing upon, but without any great injury to, other plants; as *Polyporus*, &c.

#### SECTION XXXVI.

#### GALLS AND EXCRESCENCES.

Galls and excrescences of various kinds, forms, and sizes, are met with on different parts of plants, resulting from disease in some form or other, whether induced by the puncture of an insect or not.

The artichoke gall of the oak is a bud which has been checked in its development by the puncture of an insect, and which is then converted into a gall consisting of imbricated scales, and resembling a small cone.

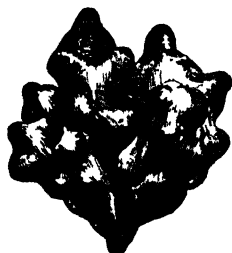


Fig. 212.

The Chinese and Japanese galls (*Fig.* 212) of commerce are leaf-galls, or cases, which ultimately contain a colony of insects.

In some parts of Europe a gall is common on one or more species of oak, in which the insect, having attacked the *cupula*, or acorn-cup, it

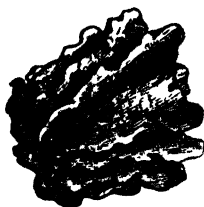
becomes developed into a curiously-shaped gall, known commercially as the knoppern (*Fig. 213*).

Some galls are formed in the substance of leaves, and ultimately burst through, and appear on the surface like flat disks, with perforations in the centre. *Oak spangles* are of this kind.

At one of the meetings of the Linnæan Society, a curious gall was shown by Dr. Farre, found on the leaves of a species of oak from Mexico. It consisted of an aggregation of hollow cylindrical tubes, nearly an inch in length, furnished with a fringed orifice. Their colour was white, suffused with red, especially towards the apex.

Galls are of two kinds, called respectively *galls* and *cases*. The *galls* are of a more or less solid or ligneous character,

and form the temporary abode of a single insect. The *cases* are hollow, and of a horny texture, and contain a colony of insects. Of the former kind are the "galls" of commerce (*Fig. 214*); the British galls, first discovered in Devonshire, but now becoming so universally diffused through England; the apple galls, or Sodom apples; and the galls found on many species of oak other than those



*Fig. 213.*



*Fig. 214.*



*Fig. 215.*

enumerated. The *cases* are represented by the commercial galls of China and Japan, the Kakrasinghee



galls of the Himalayas (*Fig. 215*), the galls of the Pistachio, Terebinth, and other species of *Rhus*, *Pistacia*, and *Terminalia*.

The majority of the galls enumerated contain a large percentage of tannin, and are, therefore, much employed in the arts; but there are others which do not contain the astringent principle. Such, for instance, are the galls found on the leaves of the elm in Southern Europe, which are sometimes the size of the fist, and contain a sweet and viscid fluid; also the *Baisonge*, found on the leaves of a species of sage in the East, which are collected and sold for food: they are sweet, and, with sugar or honey, are affirmed to make an excellent sweetmeat.

*Warts*, or *verruca* (Lat. warts), are enlarged and thickened cells, containing starch and other substances, which are developed in a globular form upon the stems of certain plants.

Monstrous developments of individual organs often assume the appearance of excrescences, and, indeed, those which we have enumerated seem to be but the result of concentrated efforts, on the part of the plant, to repair the injury it has sustained, or manifestations of disease, faintly resembling the tumorous and cancerous diseases to which the animal structure is subject.

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## SECTION XXXVII.

### VITAL ACTION.

An answer to the inquiry, "How does a plant grow?" may be fairly attempted upon the basis of the foregoing pages. The organs of plants and their functions having been described as fully as the limits of the present work would allow, it only remains to show how the structure of the plant is built up by their action.

From the soil in which the plant grows, it absorbs all its inorganic constituents dissolved in the fluid which enters the roots under the influence of endosmose. This fluid passes upwards from the roots to the leaves through the medium of the woody layers, especially the newest and most external, there to be elaborated under the influence of light.

The ascending fluid having reached the leaves, exhales much of its water in the form of vapour, through their stomata, absorbs additional carbonic acid, and, being elaborated and thickened, returns downwards by the bark and transversely by the medullary rays, depositing in its course its various contributions to the growing structure of the plant.

It must be remembered that very important changes take place in the sap during its passage through the leaves. It enters them in a crude state, and issues from them in a favourable condition for supplying all the requirements of the plant. Not only has water, but also oxygen, in considerable quantities, been exhaled, and carbonic acid has been inhaled; and thus, by the union of carbon with the hydrogen and oxygen of water in the rising sap, the descending fluid returns charged with carbonaceous secretions.

From this survey, it would seem evident that the following conditions are necessary to plant life :—

I. A soil containing all the inorganic substances which enter into the structure of the plant to be grown therein. Because the plant is unable to obtain them from any other source.

II. Sufficiency of water at the root to supply the place of that continually evaporating from the leaves, as well as a medium for the introduction of inorganic matters. Because water can only enter by the spongioles in sufficient quantity to supply that deficiency, and inorganic substances can only enter in solution.

III. Heat sufficient to evaporate the water of the ascending sap, when it becomes diffused through the leaves. Because, otherwise, the fluids of the plant would not exceed in density the water of the soil, and no endosmotic current would be established.

IV. Leaf-surface equivalent to the size of the tree. Because, otherwise, there is insufficient provision for bringing the crude sap under the influence of heat, light, and air.

V. Plenty of light to elaborate the secretions. Because, in the absence of light, plants etiolate and die ; absorption of carbon increasing relatively with intensity of light.

VI. An atmosphere containing carbonic acid gas. Because the carbon is requisite for the formation of the carbonaceous secretions, and plants exhibit a more vigorous habit in an atmosphere more than ordinarily charged with carbonic acid.

Hence, during the winter, when some of these conditions are not fulfilled, there is a cessation of growth.

The autumnal tints of leaves are believed to be due to the oxidation of their green colouring matter, or chlorophyll.

The fall of leaves is assumed to result from the choking up of their tissues by continued deposits during evaporation. Being unable to perform their functions, they become sickly, dry up, die, and, weakened at their point of attachment or articulation, fall off by their own weight, or, contracting by loss of moisture, disconnect themselves and fall.

In plant life, as in other manifestations of the Great Author of Nature, man meets with many phenomena which he is compelled to admire, but is puzzled to explain.

## SECTION XXXVIII.

## BOTANICAL DESCRIPTION.

It is a good test of the progress of the student in Botany, that he shall be able to describe a plant correctly, naming the parts with precision, and describing its features with accuracy. It is also a test of careful and correct observation, and should be the aim of every student to accomplish it well.

To dissect and examine the flower and seed, a pocket lens will be necessary.

Nothing must be taken for granted ; but every part should be carefully examined, noticing the result.

The botanical description should be as terse and compact as possible ; omitting all superfluous expressions, at the same time guarding against the use of either a wrong or a vague term.

Should the plant to be described be in flower only, it will be necessary either to examine the plant again when in fruit, to complete the description, or, if this cannot be done, let the description end with the flower. The parts should be described in the order of development.

**ROOT.**—Its form, whether conical, fibrous, &c., and also whether annual or perennial.

Care must be taken not to call tubers, rhizomes, or other underground stems, by the name of *roots*.

**STEM.**—Whether erect or prostrate, solid or fistular, cylindrical or angular, naked or pubescent, &c.

**LEAVES.**—Whether alternate or opposite, stipulate or exstipulate, radical or cauline, simple or compound, entire or serrated ; and character of venation.

**INFLORESCENCE.**—Whether racemose or cymose, ter-

nal or axillary, erect or drooping, and the nature of the bracteal appendages.

**FLOWERS.**—Commencing with the *calyx*, whether regular or irregular, monosepalous or polysepalous, persistent or deciduous, superior or inferior. *Corolla*, whether regular or irregular, monopetalous or polyetalous, sessile or unguiculate. *Stamens*, whether definite or indefinite, hypogynous or epigynous, monadelphous or polydelphous. *Filaments*, whether short or long, filiform or petaloid. *Anthers*, whether one or more celled, introrse or extrorse, innate or adnate, and whether opening by pores or valves. *Ovary*, superior or inferior, one or many celled, one or many seeded, syncarpous or apocarpous. *Style*, terminal or axillary, filiform or petaloid, persistent or deciduous. *Stigma*, whether simple or bifid, terminal or lateral. *Stamules*, whether erect or otherwise, anatropal or orthotropal, definite or indefinite. *Placenta*, whether axile or parietal.

**FRUIT.**—Indehiscent or dehiscent. If dehiscent, either by pores or valves, and if loculicidal or circumscissile, also the arrangement of the placentæ. *Shape*, whether spherical or angular, smooth or hairy, glabrous or exaluminous, whether the *albumen* is fleshy, oily, or mealy. The *embryo*, monocotyledonous or dicotyledonous, straight, annular, or spiral; whether the *radicle* is directed to the apex or base, and whether the *cotyledons* are flat, spiral, accumbent, or incumbent.

Plants should be described in conformity with the following scheme, commencing with the root and ending with the seed :—

## SCHEME.

Root .....	Character.
Stem .....	General character
Leaves.....	Arrangement.
	Stipulation.
	Composition.
	Form.
	Margin and incision.
	Venation.
Inflorescence ....	General character.
	Bracteal appendages.
Flower.....	Peculiarities of Calyx.
	.. Corolla.
	.. Stamens.
	Disk.
	Pistil (Ovary, Style, Stigma, Placentation).
Fruit.....	General character.
	Dehiscence.
	Placentation.
	Arrangement of embryo.
Habitat, or place of growth.	

## SECTION XXXIX.

## DESCRIPTIVE MODELS.

As it will be advisable that this lesson should be devoted to the practical description of plants, in conformity with the *Scheme* already given, a botanica' description, by Dr. Lindley, is appended as a model for imitation.

## CARDAMINE PRATENSIS.

N.O. Brassicaceæ.

Roots fibrous, slightly branched ; proceeding from the sides of a half-subterranean, perennial, green *tuber*, whose sides are marked by wide scars, and very short tooth-like branches

**STEM** erect, annual, smooth, terete, about a foot high.

**LEAVES:** **RADICAL**, on long stalks, thin, dark green, distantly pinnate; *leaflets* stalked, in two to four pairs, sometimes alternate, wavy, orbicular, entire, angular, or toothed; the terminal one much larger than the other; **CAULINE**, more closely pinnate, in from five to seven pairs, with an odd one; *leaflets* linear, obtuse, entire.

**RACEMES** terminal and axillary, two or three, nodding, longer than the leaves, somewhat corymbose, ebracteate.

**SEPALS** four. Oblong, obtuse, membranous at the edge: the two opposite slightly saccate.

**PETALS** four. Cruciate, pale lilac or white, veiny, with a slight tooth on one side of the unguis.

**STAMENS** tetradynamous, hypogynous, erect, longer than the calyx; *filaments* subulate, rigid, somewhat herbaceous, the two lateral much shorter than the others; *anthers* ovate, innate, erect, opening longitudinally: those of the longer filaments extrorse, of the shorter introrse.

**OVARY** superior, terete, as long as the longest filaments, two-celled; *placentæ*, two in each cell, next the dissepiment, parietal, polyspermous; *style* very short; *stigma* capitate.

**DISK:** four minute green glands; one surrounding the base of each shorter stamen, one free, between the bases of each longer stamens.

**FRUIT** (rarely produced). **SILIQUA** linear, compressed, slightly torulose; *valves* thin, flat.

**SEEDS** oblong, lenticular, bright brown, arranged in a single line, suspended from very short funicles.

**EMBRYO** exalbuminous, with a superior radicle as long as the accumbent cotyledons.

## SECTION XL

## SUMMARY.

The following Summary has been prepared in a tabular form, and, had it been found practicable to have printed it entire upon an open sheet, would have presented, at one view, the whole scope of the foregoing pages. Having carefully studied all that has preceded it, a slight effort will enable the student to comprehend this table, which will then serve as a mentor, pointing out centres around which memory will gather the results of our forty lessons.

## Ultimate Elements.

{	Oxygen.
{	Hydrogen.
{	Nitrogen.
{	Carbon.
{	Phosphorus.
{	Sulphur.
{	Chlorine.
{	Iodine.
{	Bromine.
{	Silicon.
{	Potassium.
{	Sodium.
{	Calcium.
{	Magnesium.
{	Aluminium.
{	Iron.
{	Manganese.
{	Carbon.



## Proximate Principles.

{	Cellulose.	
	Lignine.	
{	Starch . . . . .	{ Inuline.
		{ Lichenine.
	Dextrine.	
{	Sugar . . . . .	{ Cane Sugar.
		{ Grape Sugar.
		{ Mannite
{	Gum.	
	Resin.	
	Organic Acids.	
	Volatile Oils.	
	Camphor.	
	Caoutchouc.	
	Fixed Oils.	
	Wax.	
{	Fibrine.	
	Caseine.	
	Albumen.	
{	Chlorophyll—Chromule	
	Emulsine.	
	Diastase.	
	Alkaloids.	
{	Water.	
	Mineral constituents of the ashes	
	of plants.	

## Elementary Tissues.

	{	Vesicles or Cells— <b>Lacuna</b>	
{ CELLULAR . .		Parenchyma.	
	{	Fibro-cellular	
		Pitted.	
	{	Woody tissue.	
		Glandular.	
{ VASCULAR . .		Fibro-vascular . . . . .	{ Spiral vessels.
			{ Ducts.
			{ Annular vessels.
			{ Scalariform.
	{	Laticiferous	

## Nutritive Organs.

EPIDERMAL...	{ Outside.		{ Stomata. Hairs. Prickles. Stings		
	{ Epidermis .....		{ Epiblema. Epithelium.		
AXIAL .....	{ Descending ..	{ Simple .....		{ Pith or Medulla	
		{ Compound ..		{ Sheath .....	
	{ Ascending ..	{ Adventitious		{ Medullary Rays	
		{ Terrestrial ..		{ Duramen .....	
	{ Subterranean	{ Fibrils .....		{ Alburnum .....	
		{ Spongioles ..		{ Liber .....	
	{ Tubers .....	{ Exogenous ..		{ Mesophloem ..	
		{ Endogenous ..		{ Epiphloem .....	
FOLIACEOUS..	{ Thallus.	{ Acrogenous ..		{ Tendrils.	
		{ Rhizome ....		{ Ascidia.	
	{ Leaf .....	{ Flagellum ..		{ Phyllodia.	
		{ Soboles ....		{ Buds.	
	{ Stipule ....	{ Tubers .....		{ Bulbs.	
		{ Petiole .....		{ Ochrea.	
	{ Retinaculum.	{ Lamina .....		{ Thorn.	
		{ Reticulum.		{ Reticulum.	

## Reproductive Organs.

I.—*Phanerogamous*

FLORAL		Bracts.	Involucre	Epicalyx
Envelopes .....	Essentials .....	{ Calyx (Sepals) ..... Corolla (Petals) ..... Stamens ..... Pistil ..... Columns ..... Ovary .....	{ Perianth or Perigone Anther .... Filament. Stigma Style Ovary .....	{ Pollen- grains Fovola Carpels. Ovules.
			{ Pericarp ..... Seed.....	{ Epicarp .... Mesocarp .. Endocarp Spermatoderm Albumen Embryo ....
POMONAL.....				

II.—*Cryptogamous.*

<b>PILICAI</b> .....	{ Theca .....	{ Spores .....	{ Antheridia .....	Spermatozoids.
	{ Indusium.		{ Archegonia .....	Germ-cell.
	{ Annulus.			
<b>MUSCICAI</b> .....	{ Perigone. ....	{ Antheridium .....	Spermatozoid.	
	{ Paraphyses	{ Sporangium ..	{ Operculum	
	{ Epigone .....	{ Archegonia ....	{ Seta .....	{ Columnella.
			{ Theca .....	{ Calyptra.
			{ Thalamium ....	{ Vaginula.
			{ Apothecia ....	{ Sporidia.
			{ Exeiple.	
<b>LICHENAL</b> .. ...	{ Pycnidia .....		Stylospores .....	Spores.
	{ Spermagonia .....		Spermatophores ..	Spermatia—Gonidia.
	{ Hymenium ....	{ Basidia ....	Spores.	
		{ Paraphyses.		
<b>FUNGICAI</b> .. ...		Spermagonia .....	Spermatia.	
		Pycnidia .....	Stylospores.	
	{ Triraspores ...	{ Conceptacles ..	Perispore ....	Sporules
		{ Stichidia .....		
<b>ALGAL.</b> .....		Ceramidium .....		Spores
		Antheridia .....		Spermatozoids.
		Sporangia .....		Zoospores.



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